CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 53 JULY 1967 NUMBER 3

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CALIFORNIA FISH AND GAME

VOLUME 53 JULY 1967 NUMBER 3

Published Quarterly by
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME

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Calif. Fish and Game, 53 (3) : 132-145, 1967.

SECOND COOPERATIVE SURVEY OF THE CALIFORNIA CONDOR[1]

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The second annual California condor (*Gymnogyps californianus*) survey was conducted October 18 and 19, 1966. Forty-five sightings were reported by 15 of 65 stations manned on October 18, 1966. One hundred twenty-two sightings were reported by 23 of 65 stations manned on October 19, 1966. These sightings, by an evaluation of the reports, were reduced to a population index of 29 and 51 individual birds, respectively, for the 2-day survey. An increase of 13 birds on the second day over the count of 38 in 1965 does not necessarily indicate an increase in the condor population. Better weather, placement of stations, and an increase in the number of observers were factors that could contribute to the increased number tallied in 1966. It becomes increasingly evident that comparative weather conditions are the most important variable affecting this survey. The different results experienced on the first and second days of the 1966 count bear this out. During the second day of the survey 14 young birds were observed, which is approximately 30 percent of the population index. This indicates a satisfactory rate of reproduction.

INTRODUCTION

The first cooperative survey of the California condor *(Gymnogyps californianus)* was conducted in October 1965 (Mallette and Borneman, 1966). The survey procedures are coordinated by a Condor Survey Committee representing the California Department of Fish and Game, U. S. Fish and Wildlife Service, U. S. Forest Service, National Audubon Society, University of California, and other conservation interests.

Objectives of the survey are to: (i) establish periodic condor population counts which will provide an index to the population; (ii) gain an indication of nesting success based on the age classification of birds observed; (iii) obtain more information on the distribution of condors; (iv) foster public awareness of the precarious status and problems related to the protection of the species; and (v) gain other knowledge on condors and raptors as incidentally provided by such survey.

[1] Submitted for publication April 1967. A contribution from Federal Aid in Wildlife Restoration Project W-47-R, "Upland Game Investigations".

[2] Prepared for and with approval of the Condor Survey Committee: Chairman Ben Glading, Chief of Wildlife Management Branch, California Department of Fish and Game; A. Starker Leopold, Professor of Zoology, University of California, Berkeley; William P. Dasmann, U. S. Forest Service; John E. Chattin, U. S. Fish and Wildlife Service; John C. Borneman, National Audubon Society; Fred C. Sibley, U. S. Fish and Wildlife Service; and Robert D. Mallette, California Department of Fish and Game.

METHODS

The methods and evaluation procedures were essentially as reported for the 1965 survey (Mallette and Borneman, 1966). Changes in the 1966 survey were: (i) nine sector captains were selected to coordinate survey details with observers; (ii) two observers were assigned to each of the 65 stations; (iii) all observers were asked to call sector captains each evening, reporting the daily results, and a summary was relayed to the evaluation center; and (iv) survey results were released 24 hours after survey was completed.

Criteria for ruling out sighting duplications were those used in 1965 and were based on: time of observations, direction of flight, grouping of birds of known age and plumage characteristics, distance between stations, normal condor flight patterns, and resting and roosting locations.

Observation stations are listed in Appendix A and shown in Figure 1.

WEATHER

The temperatures during the survey were warmer than last year, averaging 20 F warmer on the first day of the survey and 13 F warmer on the second (Table 1). The winds were generally from the south over much of the census area on both days of the survey and were somewhat stronger on the second day. Observers reported that soaring conditions were more favorable on the second day of the survey.

TABLE 1

U.S. Forest Service Lookout Stations Reporting Weather Information Which Were Also Condor Survey Stations

Readings Were Taken 2 p.m. October 18 and 19, 1966

October 18

Lookout station	County	Average wind velocity (miles per hour)	Direction of wind	Temperature (F)	Relative humidity
Thorn Point	Ventura	6	SW	70	12
Nordhoff	Ventura	10	SE	78	11
McPherson	Santa Barbara	6	E	68	13
Figueroa	Santa Barbara	8	SW	82	10
Hi Mountain	San Luis Obispo	8	SW	81	7

October 19

Thorn Point	Ventura	10	SW	69	8
Norhhoff	Ventura	8	E	80	10
McPherson	Santa Barbara	18	SW	71	8
Figueroa	Santa Barbara	10	SW	81	9
Hi Mountain	San Luis Obispo	16	S	77	5

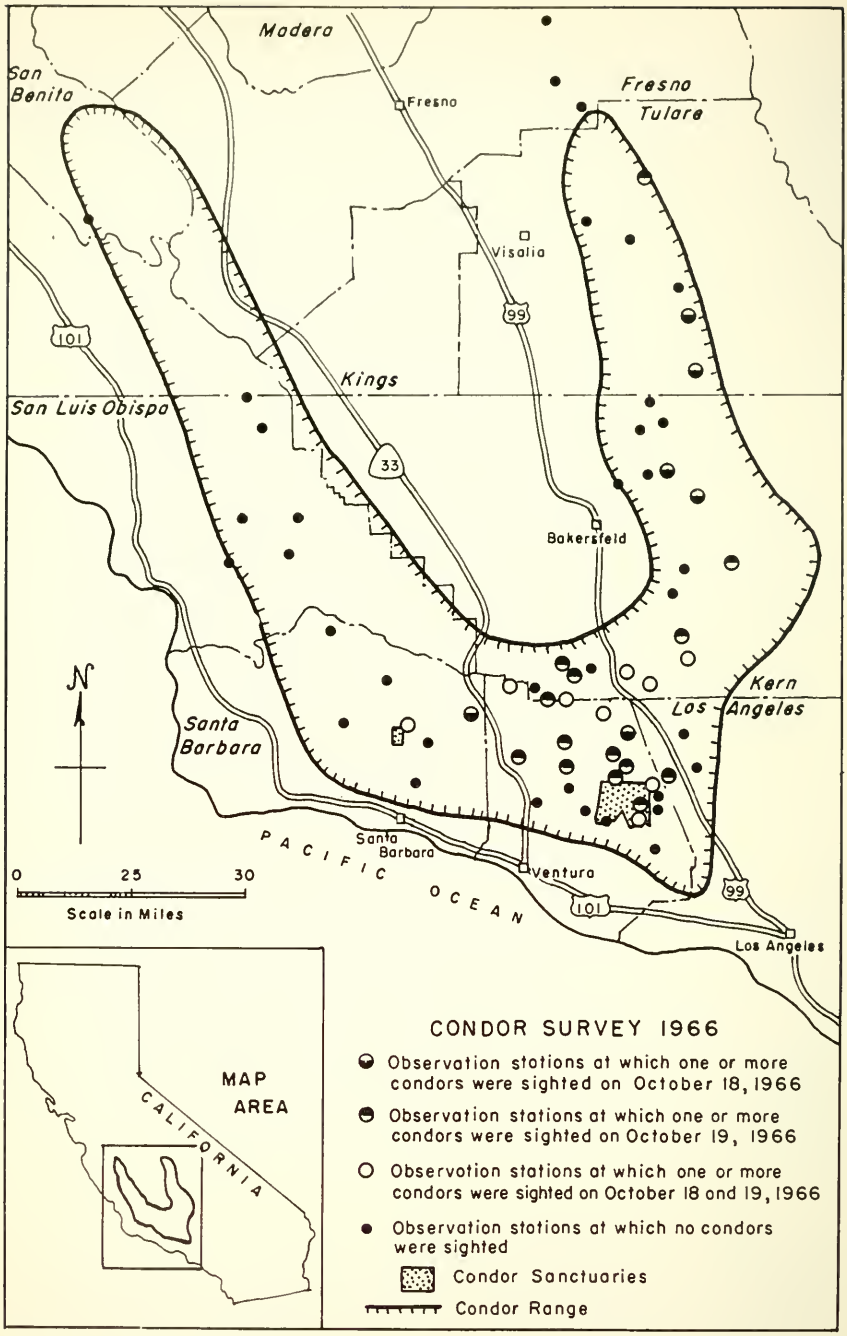

FIGURE 1—Location of condor survey observation stations and the locations where condors were sighted on October 18 and 19, 1966. *Drawing by Cliffa Corson.*

RESULTS

On each day of the survey 65 stations were manned by 133 observers. On October 18, 45 condor sightings were reported from 15 stations (Appendix B). These sightings, by an evaluation of the reports, were reduced to 29 individual condors. The age classification breakdown was: 2 juveniles, 1 subadult, 17 adults, and 9 unknown. An estimated 877 raptors of 13 species were also reported on the first day of the survey (Table 2).

On October 19, 122 condor sightings were reported from 23 stations (Appendix C). By an evaluation of the reported sightings, 51 individual condors were seen. The age classification breakdown was: 6 juveniles, 5 immatures, 3 subadults, 33 adults, and 4 unknown. The observers also reported an estimated 955 raptors of 13 species (Table 2).

TABLE 2

Raptors Reported During Condor Survey October 18–19, 1966

Species	Date reported	
	Oct. 18	Oct. 19
Turkey vulture (*Cathartes aura*)	357	375
Golden eagle (*Aquila chrysaetos*)	85	105
Bald eagle (*Haliaeetus leucocephalus*)	2	3
Goshawk (*Accipiter gentilis*)	5	2
Sharp-shinned hawk (*A. striatus*)	24	24
Cooper's hawk (*A. cooperii*)	29	35
Red-tailed hawk (*Buteo jamaicensis*)	214	229
Swainson's hawk (*B. swainsoni*)	25	27
Rough-legged hawk (*B. lagopus*)	2	3
Pigeon hawk (*Falco columbarius*)	3	3
Sparrow hawk (*F. sparverius*)	64	80
Prairie falcon (*F. mexicanus*)	7	9
Marsh hawk (*Circus cyaneus*)	10	8
Miscellaneous raptors	50	52
Total	877	955

DISCUSSION

As in the case of the 1965 survey, no attempt to project the population index to a total condor population figure was made. A number of variables occur which prevent us from doing this; chief among these is the rugged terrain in the condor range which makes it difficult to detect and count all condors moving through or roosting in the area.

It is imperative that survey methods providing comparable survey data from year to year be established. Although evaluation techniques have been the same for both surveys, the present survey results do not provide fully comparable data. Additional experimentation and changes in survey procedure are necessary for survey results which will be more comparable.

On October 19 conditions were favorable to put more birds in the air than on October 18. The major variable influencing condor movements apparently is weather. During the 1966 survey the average temperature was approximately the same both days; the average wind velocities were approximately 5 miles an hour greater on the 19th than on the 18th, and a shift in wind direction was noted at some observation stations. These weather changes, even though slight, can alter soaring or flying conditions in the rugged terrain which these birds inhabit. Weather is still an unknown variable, and it may be necessary to have a longer survey period to assure at least one day of favorable weather conditions. Until we better understand these factors, it will be difficult to obtain a comparable population index from annual surveys.

An increase of 13 condors counted in 1966 compared with 1965 does not necessarily represent a population increase. The report of 51 condors in 1966 shows there are more than the 40 birds estimated earlier by Miller, McMillan, and McMillan (1965). Survey results neither substantiate nor refute the claim of these writers that a population decline of one-third had occurred since the 1940's. Earlier estimates, based on single high counts of birds or simultaneous sightings by a few observers, may have been conservative; or the 1966 survey results may be reflecting a population increase; or both.

During the 1966 survey 14 young birds (approximately 30%) were observed, indicating a satisfactory rate of reproduction. Six of these were reported as juveniles and were birds hatched in 1965. Because of the difficulty of accurately differentiating the juvenile age class from the subadult class, caution must be used in analyzing these data.

The late summer distribution of the condor population as shown by the two annual surveys is consistent with that determined from scattered observer reports for this time of year. Using the survey results of October 17, 1965, and October 19, 1966, only 10% and 2%, respectively, of all birds observed were seen west of U. S. Highway 33, in the western portion of the condor range. Forty-five percent of the condor population observed both years was in the vicinity of the Sespe Condor Sanctuary, Ventura County, and 45% and 53%, respectively, was in the Tehachapi Mountains in Kern County and the eastern portion of the condor range (Figure 1).

In both years the major feeding area was in the Tehachapi Mountains on the Tejon Ranch, Kern County, pointing out the need for additional coverage in this area in order to obtain data to better evaluate the survey results. Observers at station 50A on Purdy Ridge reported 53 condor sightings in addition to numerous other raptors on October 19. Eight condors were in the air at one time, making it very difficult for two observers to take detailed notes. Provisions are needed whereby assistance can be given to observers manning stations when such a concentration occurs.

RECOMMENDATIONS

Seven suggestions for improving subsequent condor surveys are:

1) More observation stations are needed on the Tejon Ranch property in the Tehachapi Mountains, Kern County, in the vicinity of station 50A to provide better coverage in this key condor feeding area.

2) Additional fire lookouts situated along the Sierra foothills, most of which are manned by the California Division of Forestry, should be incorporated as survey stations. Discussions with Division of Forestry personnel indicated this is possible.

3) Two observers should be located at each station where large numbers of condor sightings have been or are likely to be seen. At peripheral condor range stations the number of observers should be reduced to one per station. At stations where an unusually large concentration of condors occurs, standby observers should be available to assist in keeping track of birds and recording sightings.

4) A review of the observer list should be made so that good experienced observers need not be given the routine training designed for inexperienced observers. A field session should be continued as part of the training program for inexperienced observers. The special training session for sector captains should be continued to properly coordinate the survey.

5) The survey headquarters should be moved from Ventura to suitable quarters in the Bakersfield area. This is more centrally located to the survey area and is closer to the areas where maximum condor activity occurs.

6) Experimental feeding should be initiated under close supervision to determine its practicality as a survey method. If successful, it may be possible to conduct the annual survey with fewer observation stations and have more comparable data from year to year.

7) Alternate survey dates should be established well in advance of the survey in the event a cancellation is necessary because of bad weather and/or other factors. If poor observing conditions also exist on the alternate dates, the survey should be cancelled for that year.

ACKNOWLEDGMENTS

The Condor Survey Committee wishes to thank all the people who participated in the condor survey; without them this survey could not have been possible. The return of many persons who participated in last year's survey added much to the reliability of the survey results. The continued cooperation from the National Audubon Society, U. S. Forest Service, U. S. Fish and Wildlife Service, California Department of Fish and Game, California Division of Forestry, Sequoia National Park, and interested ranchers and conservationists is greatly appreciated.

REFERENCES

Koford Carl B. 1953. The California condor. New York, National Audubon Society, Res. Rept., (4) : 154 p.

Mallette, Robert D., and John C. Borneman. 1956. First cooperative survey of the California condor. Calif. Fish and Game 52(3) : 185–203.

Miller, Alden H., Eben McMillan, and Ian McMillan. 1965. The status and welfare of the California condor. New York, National Audubon Society, Res. Rept., (6) : 61 p.

APPENDIX A

Second Cooperative Condor Survey Observation Stations
Manned October 18 and 19, 1966

(Stations marked with an asterisk reported one or more condors)

San Benito County

1. Bitterwater, 1 mile south of store on Maggini Ranch.

San Luis Obispo County

2. Cholame Flat near San Luis Obispo-Monterey county line.
3. Eben McMillan Ranch, in the Palo Prieto area.
4. 1 mile east of La Panza Ranch hdqrs. at San Juan Creek road crossing.
5. Upper Beartrap Canyon.
6. La Panza Ranch, 2 miles south of Beartrap Canyon (used in 1965 but eliminated in 1966).
7. Black Mtn. Lookout.
8. Hi Mtn. Lookout.

Santa Barbara County

9. Miranda Pine Mtn., northwest end of Sierra Madre Ridge.
10. McPherson Peak Lookout.
*11. Cuyama Peak Lookout.
12. Figueroa Mtn. Lookout.
13. Sisquoc Sanctuary area, 2 miles east of the South Fork Guard Station and 200 yards up slope from Sisquoc Canyon Trail across canyon from Sisquoc Falls (eliminated).
*13a. Sisquoc Sanctuary area, 2 miles northeast of sanctuary on Sand Springs Ridge (replaces Station 13).
14. West Big Pine Lookout.
14a. Cuyama Valley and Foothill Road (eliminated).
14b. La Cumbre Lookout (added in 1966).

Ventura County

*15. Frazier Mtn. Lookout.
*16. Maxey Ranch in Hungry Valley, 5 miles southwest of Gorman.
17. Alamo Mtn. Summit Road (eliminated).
*18. Mutah Road near San Guillermo Mtn.
*19. Reyes Peak.
*20. Thorn Point Lookout.
*21. Head of Agua Blanca Canyon on trail about 1 mile north of Bucksnort Camp.
*21a. McDonald Peak.
*22. Squaw Flat Road near Squaw Flat.
*23. Hopper Mtn., Pemberton Rock.
*23a. Hopper Mtn., Percy Ranch.
*24. Upper Reasoner Canyon.
24a. Reasoner Canyon on Dale King Ranch.
24b. Dominguez Canyon (added).
25. Lower Agua Blanca Creek at Hollister Cabin Camp (eliminated).
26. San Cayetano Peak and Pine Canyon where San Cayetano Road crosses saddle midway down ridge leading east from peak to Sespe Creek.
27. Hines Peak area at end of road in saddle on northwest side of peak.

28. Santa Paula Canyon on trail 1 mile north of Cross Camp.
29. Nordhoff Peak Lookout.
30. Strathearn Ranch in Simi Valley (eliminated).
30a. Torrey Mtn. (replaces Station 30).

Los Angeles County

31. Whitaker Peak Lookout.
32. West Liebre Lookout.
32a. Antelope Valley (eliminated).
32b. Warm Springs Lookout (replaces Station 32a).

Fresno County

33. Delilah Lookout, 5 miles north of Dunlap.
33a. Fence Meadow Lookout.
33b. Stony Flat, 2 miles north of Pinehurst.

Tulare County

*34. Milk Ranch Lookout.
35. Blue Ridge Lookout.
36. Solo Peak, 8 miles southeast of Springville.
36a. Solo Peak near Rogers Camp (eliminated).
*37. Mule Peak Lookout.
*38. Tobias Peak Lookout.
38a. Lindcove area on the Mehrten Ranch.

Kern County

39. Blue Mtn. Lookout, 5 miles northeast of Woody.
40. Farnsworth Ranch, 2 miles south of Glennville.
41. Dead Ox Ridge, about 4 miles south of Woody.
42. Round Mtn., 3 miles northeast of Granite Station.
43. Rattlesnake Ridge on the John Rofer Ranch, 4 miles west of Oak Flat Lookout.
*44. Oak Flat Lookout.
*45. Breckenridge Mtn. Lookout.
*46. Tollgate Lookout.
47. White Wolf Corrals.
48. Comanche Pt., 4 miles southeast of Arvin on Tejon Ranch.
*49. 2 miles east of Grapevine Station and 4 miles southeast of Wheeler Ridge on Tejon Ranch ostrich farm.
*50. 2 miles east of Fort Tejon at Tejon Ranch airline beacon.
*50a. Purdy Ridge, 2 miles west of Lopez Flats on the Tejon Ranch.
*51. Cordon Ridge on Tejon Ranch.
52. Pleito Hills overlooking Wheeler Ridge and Salt Creek on San Emigdio Ranch.
*54. Ridge to west of big flat at head of Pleitito Canyon on San Emigdio Ranch.
*55. Teeuya Ridge, 2 miles north of Lake of Woods in Cuddy Valley.
*56. Mt. Pinos, east end of summit.
*57. Mt. Pinos, west end of summit.
58. Mt. Abel.
59. Brush Mtn., 4 miles north of Mt. Abel (eliminated).
*60. Santiago Canyon on Snedden Ranch.
61. Apache Potrero on Snedden Ranch (eliminated).

APPENDIX B

Summary of Condor Survey Reports, October 18, 1966

(Time is Pacific Daylight Savings Time)

Condor number	Age classification	Observation station	Sighting number	Reported time and duration of observation	Reported distance from observer	Reported direction of flight	Remarks
1	Unknown	16	1	0822	2 miles	Southeast	
2	Unknown	41	2	0908-0912	¾ mile	North	
3	Adult	49	3	0925-0930	200 ft.	East	Sighted five times from two stations.
		50	4	0946-0959	2 miles	Northeast	
		49	5	1010-1012	½ mile	North	
		49	6	1022-1025	2 miles	North	
		50	7	1148-1155	3 miles	North to northeast	
4	Adult	11	8	1041-1046	3 miles	South to east-northeast	
5	Adult	56	9	1123-1145	½ mile	West to east	
6	Adult	50A	10	1213-1215	½ mile	East	Sighted twice traveling with condor 7.
		50A	11	1537	1 mile	East	
7	Adult	50A	12	1213-1215	½ mile	East	Sighted twice traveling with condor 6.
		50A	13	1537	1 mile	East	
8	Adult	24	14	1215	1½ miles	Northwest to southeast	
9	Unknown	50	15	1241-1242	3 miles	South	
10	Adult	15	16	1247-1250	¾ mile	North	
11	Adult	15	17	1251-1257	¾ mile	West	
12	Unknown	23A	18	1326	½ mile	North	
13	Adult	60	19	1328-1345	800 yds.	Northwest to southeast	
14	Juvenile	50	20	1420-1438	1 mile	Circling	Traveling with condors 15, 16, 17, 18, 19.
		50A	21	1622-1627	2 miles	North	Single bird.

15	Adult	50	22	1420–1438	1 mile	Circling	Traveling with condors 14, 16, 17, 18, 19.
		50A	23	1613–1618	½ mile	East	Single bird.
16	Adult	50	24	1420–1438	1 mile	Circling	Traveling with condors 14, 15, 17, 18, 19.
		50	25	1628–1638	1–5 miles	South to southwest	Traveling with condors 17, 18, 19.
17	Adult	50	26	1420–1438	1 mile	Circling	Traveling with condors 14, 15, 16, 18, 19.
		50	27	1628–1638	1–5 miles	South to southwest	Traveling with condors 16, 18, 19.
18	Unknown	50	28	1420–1438	1 mile	Circling	Traveling with condors 14, 15, 16, 17, 19.
		50	29	1628–1638	1–5 miles	South to southwest	Traveling with condors 16, 17, 19.
19	Unknown	50	30	1420–1438	1 mile	Circling	Traveling with condors 14, 15, 16, 17, 18.
		50	31	1628–1638	1–5 miles	South to southwest	Traveling with condors 16, 17, 18.
20	Adult	45	32	1437–1442	¼ mile	North	
21	Adult	50A	33	1507–1512	200 yds.	East	
22	Adult	50A	34	1512–1517	100 yds.	East	
23	Unknown	15	35	1517–1523	2 miles	South	Traveling with condor 24.
		24	36	1602	1½ miles	Northwest to southeast	Single bird.
24	Unknown	15	37	1517–1523	2 miles	South	Traveling with condor 23.
		24	38	1608–1616	1½ miles	West to east	Single bird.
25	Subadult	45	39	1525–1535	¼ mile	South to southeast	
26	Unknown	15	40	1527–1529	2 miles	South	
27	Juvenile	38	41	1531–1536	6 miles	North	Sighted three times from two stations.
		37	42	1600	1 mile	North	
		37	43	1700	200 yds.	South	
28	Adult	13A	44	1600	250 yds.	Circling	Traveling with condor 29.
29	Adult	13A	45	1600	250 yds.	Circling	Traveling with condor 28.

APPENDIX C

Summary of Condor Survey Reports, October 19, 1966

(Time is Pacific Daylight Savings Time)

Condor number	Age classification	Observation station	Sighting number	Reported time and duration of observation	Reported distance from observer	Reported direction of flight	Remarks
1	Adult	21A	1	0944–0947	5 miles	Circling north	
		21A	2	0952–0958	5 miles	Circling north	Traveling with condor 6.
		15	3	1515–1518	4 miles	Circling southwest	Traveling with condor 6.
2	Adult	51	4	0945–1000	5 miles	West	Traveling with condors 3, 4, 5.
		49	5	1022–1023	1 mile	South	Single bird.
		49	6	1035–1040	1 mile	North	Traveling with condors 3, 4, 5.
		50A	7	1406	200 yds.	Southeast	Single bird.
3	Adult	51	8	0945–1000	5 miles	West	Traveling with condors 2, 4, 5.
		49	9	1035–1045	1 mile	Southeast	Traveling with condors 2, 4, 5.
		50	10	1244–1255	2 miles	East to north	Single bird.
		50A	11	1420–1427	200 yds.	East	Single bird.
		50A	12	1428–1435	1 mile	Dispersed	Traveling with condors 17, 18, 19, 25, 26.
		50A	13	1535–1545	150 yds.	Northwest	Traveling with condors 29, 30, 31, 32.
4	Adult	51	14	0945–1000	5 miles	West	Traveling with condors 2, 3, 5.
		49	15	1035–1045	1 mile	Southeast	Traveling with condors 2, 3, 5.
		50	16	1253–1255	2 1/2 miles	East to north	Single bird.
		50A	17	1405	200 yds.	Southeast	Single bird.
5	Adult	51	18	0945–1000	5 miles	West	Traveling with condors 2, 3, 4.
		49	19	1035–1045	1 mile	Southeast	Traveling with condors 2, 3, 4.
		50	20	1120–1124	3 miles	North	Traveling with condor 15.
		50A	21	1410–1415	200 yds.	Southeast	Traveling with condor 15.
6	Adult	21A	22	0952–0958	5 miles	Circling north	Sighted twice from two stations, traveling with condor 1.
		15	23	1515–1518	4 miles	Circling southwest	
7	Juvenile	23A	24	1011–1019	3/4 mile	North	Sighted five times from four stations, traveling with condor 8.
		23A	25	1027	1/2 mile	Northeast	
		22	26	1140–1141	1 1/4 miles	Northwest	
		21A	27	1155–1158	5 miles	Circling north	
		24	28	1602–1610	1 1/2 miles	North	
8	Adult	23A	29	1011–1019	3/4 mile	North	Sighted five times from four stations, traveling with condor 7.
		23A	30	1027	1/2 mile	Northeast	
		22	31	1140–1141	1 1/4 miles	Northwest	
		21A	32	1155–1158	5 miles	Circling north	
		24	33	1602–1610	1 1/2 miles	North	

9	Adult	50A	34	1023–1034	½ mile	Circling	Sighted four times from two stations, traveling with condor 10.
		50A	35	1040–1055	½ mile	West	
		50	36	1140–1146	1 mile	North	
		50A	37	1310–1315	200 yds.	Southeast	
10	Adult	50A	38	1023–1034	½ mile	West	Sighted four times from two stations, traveling with condor 9.
		50A	39	1040–1055	½ mile	West	
		50	40	1140–1146	1 mile	North	
		50A	41	1310–1315	200 yds.	Southeast	
11	Adult	13A	42	1024–1029	5½ miles	North	
12	Adult	31	43	1026–1031	½ mile	North	
13	Unknown	34	41	1035–1045		East	
14	Adult	50A	15	1040–1055	½ mile	West	
15	Adult	49	46	1055–1100		East	
		50	17	1120–1124	3 miles	North	Traveling with condor 5.
		50A	18	1410–1415	200 yds.	Southeast	Traveling with condor 5.
16	Immature	46	49	1105–1106	½ mile	Northwest	
17	Adult	50A	50	1105	½ mile	East	
		50A	51	1128–1135	1 mile	Dispersed	Traveling with condors 3, 18, 19, 25, 26.
		50A	52	1524–1530	150 yds.	West	Traveling with condors 18, 19.
18	Adult	50A	53	1106	½ mile	East	Traveling with condor 19.
		50A	54	1328–1333	200 yds.	East	Single bird.
		50A	55	1128–1135	1 mile	Dispersed	Traveling with condors 3, 17, 19, 25, 26.
		50A	56	1524–1530	150 yds.	West	Traveling with condors 17, 19.
19	Adult	50A	57	1106	½ mile	East	Traveling with condor 18.
		50A	58	1128–1135	1 mile	Dispersed	Traveling with condors 3, 17, 18, 25, 26.
		50A	59	1524–1530	150 yds.	West	Traveling with condors 17, 18.
20	Adult	49	60	1107–1115	1 mile	North to northwest	
		49	61	1200–1201	1 mile	West	
		49	62	1313	1 mile	South to east	In sight from station 50 at same time.
		50	63	1309–1319	3 miles	Southeast	In sight from station 49 at same time.
		50	64	1600–1612	2 miles	North to northeast	
21	Adult	23A	65	1110	½ mile	North	
22	Immature	23A	66	1113	½ mile	North	
		21	67	1205–1206	½ mile	West	
23	Adult	50A	68	1120	½ mile	South	Traveling with condors 24, 25, 26.
		50A	69	1305	1 mile	Northwest	Single bird.

APPENDIX C—Continued

Summary of Condor Survey Reports, October 19, 1966

(Time is Pacific Daylight Savings Time)

Condor number	Age classification	Observation station	Sighting number	Reported time and duration of observation	Reported distance from observer	Reported direction of flight	Remarks
24	Adult	50A	70	1120	½ mile	East	Traveling with condors 23, 25, 26.
		50A	71	1320–1326	1 mile	East	Single bird.
25	Adult	50A	72	1120	½ mile	East	Traveling with condors 23, 24, 26.
		50A	73	1328–1333	200 yds.	East	Traveling with condor 26.
		50A	74	1128–1135	1 mile	Dispersed	Traveling with condors 3, 17, 18, 19, 26.
		50A	75	1518–1521	½ mile	North	Single bird.
26	Adult	50A	76	1120	½ mile	East	Traveling with condors 23, 24, 25.
		50A	77	1328–1333	200 yds.	East	Traveling with condor 25.
		50A	78	1128–1135	1 mile	Dispersed	Traveling with condors 3, 17, 18, 19, 25.
		50A	79	1521–1521	100 yds.	Southeast	Single bird.
27	Adult	21	80	1120–1130	1 mile	Northeast	
		21	81	1540–1558	400 yds.	West	
28	Unknown	15	82	1129–1131	3 miles	North	
29	Adult	50A	83	1140	½ mile	South	Traveling with condor 30.
		50A	84	1535–1545	150 yds.	South	Traveling with condors 3, 30, 31, 32.
30	Adult	50A	85	1140	½ mile	South	Traveling with condor 29.
		50A	86	1535–1545	150 yds.	Northwest	Traveling with condors 3, 29, 31, 32.
		50A	87	1550	2 miles	South	Single bird.
31	Adult	50A	88	1150	½ mile	East	Traveling with condor 32.
		50A	89	1535–1545	150 yds.	Northwest	Traveling with condors 3, 29, 30, 32.
32	Adult	50A	90	1150	½ mile		Traveling with condor 31.
		50A	91	1535–1545	150 yds.	Northwest	Traveling with condors 3, 29, 30, 31.
33	Adult	22	92	1159–1200	1 mile	Northwest	
		21A	93	1225–1237	5 miles	Circling north	
34	Juvenile	50A	94	1203–1206	200 yds.	East	
		50A	95	1428–1435	100 yds.	West	

35	Subadult	50	96	1230–1231	150 ft.	Northeast
		50A	97	1300–1305	200 yds.	West
		50A	98	1333–1355	200 yds.	North
		50A	99	1128–1435	75 yds.	West
36	Juvenile	18	100	1238–1242	1 mile	North
		18	101	1350–1358	4 miles	North
		57	102	1410–1412	½ mile	North
37	Juvenile	21A	103	1242–1245	500 yds.	North
38	Immature	50	104	1253–1258	3 miles	Northeast to north
39	Unknown	46	105	1320–1332	4–6 miles	Southeast
40	Juvenile	23	106	1330–1407	½ mile	South
41	Adult	15	107	1332–1333	½ mile	South
		20	108	1520–1523	7 miles	Circling
42	Adult	60	109	1347–1403	3 miles	South
43	Adult	60	110	1408–1411	2 miles	South
		60	111	1138–1441	2 miles	Northwest to north
		51	112	1535	5 miles	South
		60	113	1610–1615	2 miles	Southeast
44	Juvenile	50A	114	1108–1110	200 yds.	Southeast
45	Immature	60	115	1411–1432	2 miles	Southeast
46	Adult	50A	116	1139–1444	½ mile	Northwest
47	Adult	19	117	1150–1152	400 yds.	West
48	Subadult	55	118	1501–1504	1 mile	Southwest
		56	119	1555–1710	¾ mile	Roosting
49	Subadult	50A	120	1555–1600	200 yds.	West
50	Adult	56	121	1555–1710	¾ mile	Roosting
51	Immature	19	122	1740–1743	200 yds.	East

Calif. Fish and Game, 53 (3) : 146-153, 1967.

THE PROBABLE AFFINITIES OF A WOLF CAPTURED NEAR WOODLAKE, CALIFORNIA[1]

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A study of the physical characteristics of a wolf killed near Woodlake, California, in 1962 suggests that the animal was introduced by man. Statistical comparison of the skull with those of living races showed that it was highly different from western North American wolves, and different in several measurements from the eastern race. It was most like the race of wolves from Southeast Asia.

On March 23, 1962, an adult male wolf *(Canis lupus)* was killed by Mr. David Boas near Woodlake in Tulare County, California (Ingles, 1963). This occurrence stirred considerable interest, since wolves were thought to have been extinct in California for about 40 years; the last known specimen had been taken in 1924 (Grinnell, 1933). Ingles (1963) suggested that the Woodlake wolf might be one of a small remnant of wolves in the remote portions of the southern Sierra Nevada, and he listed various sight reports as evidence. When the Woodlake specimen was received in the Museum of Vertebrate Zoology, a study of its probable relationships was undertaken.

METHODS

The skull was compared with specimens in the MVZ collection visually and by measurements. Measurements of the MVZ specimens were combined with published measurements taken primarily from Young and Goldman (1944) for the New World forms and from Pocock (1935) for the Old World forms. However, the more recent revision of Old World races by Ellerman and Morrison-Scott (1951) was followed. Old World forms were considered in light of the possibility of an introduction. Most of the races from the far north (both New and Old Worlds) were not compared statistically because of their much larger size. These greatly exceed the largest forms compared with the Woodlake skull.

Statistical comparisons of the Woodlake skull with adult males of the various races were made using the "t-test" as given by Simpson, Roe, and Lewontin (1960) for comparing a single specimen with a larger known population. The statistic is:

$$t = \frac{(\overline{X} - X)\sqrt{\frac{N}{N+1}}}{s}$$

which follows the t-distribution with $N - 1$ $(= 1 + N - 2)$ degrees of freedom, where $\overline{X}$ is the mean of the sample, X the value of the single

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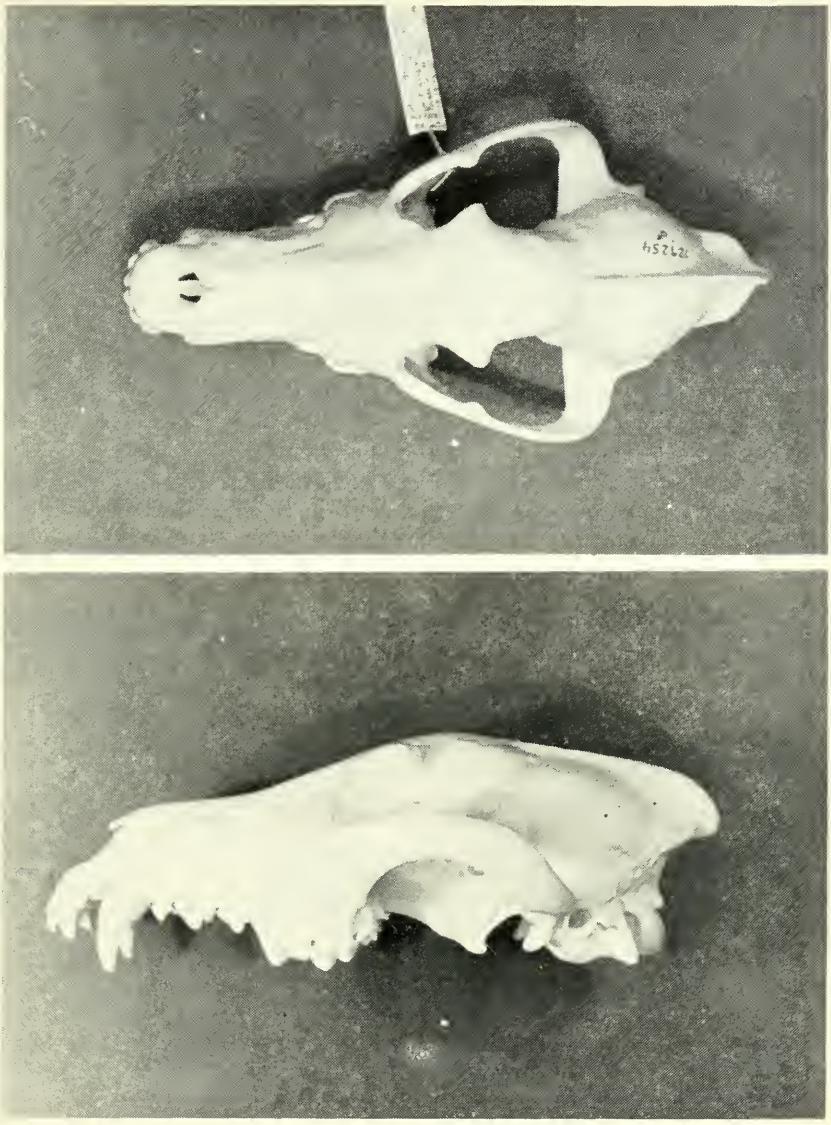

FIGURE 1—Top and side views of the Woodlake wolf skull. Note the extreme slenderness in form, as manifested in triangular shaped (instead of flaring) zygomatic arches, long narrow muzzle, constriction in the brain region, and rearward projection of the sogital crest and supraoccipital shield.

observation, s the standard deviation of the sample, and N the sample size. No statistical tests were made when the sample size was less than five.

Only general comparisons of external body measurements were made and, because of the great variation in the color of wolves, little reliance was placed on this character.

FIGURE 2—Comporison of the Woodlake wolf skull (center) with typicol specimens of the most similar North American races—*lycaon* (left) and *baileyi* (right). Difference in color of the bone is due primorily to methods of preparation.

RESULTS

Description of the Woodlake Wolf

The Woodlake wolf is clearly *C. lupus* but is a relatively small specimen for the genus as a whole. It weighed 56 pounds in the flesh and was not emaciated. Body measurements as given by Ingles (1963) are: total length, 1,500 mm; tail, 400 mm; hind foot, 255 mm; ear (notch), 105 mm; shoulder height, 750 mm. In color, the specimen was salt-and-pepper gray.

The skull in general form was exceptionally slender (Figures 1 and 2). In breadth measurements, the Woodlake specimen was narrower in relation to its length than nearly all other male specimens in both the MVZ collection and the published data (Tables 1 and 2).

Of special interest was the presence of a chalky deposit on the teeth, which, unfortunately, was removed in the cleaning process. Mr. Ward C. Russell, preparator for the Museum for many years, observed that in his experience such deposits were usually found on the teeth of animals held in captivity.

Statistical Comparison of Skulls

The Woodlake wolf skull is similar to those of only two races of wolves in North America: *baileyi* and *lycaon* (Table 1). However, the Woodlake skull differs in a statistically significant way from each of these in two of the measurements taken.

Published measurements of Old World wolves are much less satisfactory (Table 2). Adequate samples for statistical comparison are available for only three races: *lupus*, *chanco*, and *pallipes*. The Woodlake wolf skull is clearly smaller than *lupus* and larger than *pallipes* (Table 2). Of the Old World forms only *chanco* and *signatus* are similar to the Woodlake specimen. The others, although the sample size is small, appear to be either much larger or much smaller.

TABLE 1

Comparison of Some Skull Measurements of the Woodlake Wolf With Those of Adult Male Wolves of New World Races

	Sample size	Means of measurements (mm), and t-values from statistical comparisons (listed immediately below the means)					
		Condylobasal length	Zygomatic width	Squamosal constriction	Rostral width	Interorbital width	Mandible length
Woodlake wolf		220.0	121.1	71.6	41.0	40.9	172.0
lycaon (Great Lakes)	19	231.1 1.51[2]	133.9 2.46[4]	76.5 2.58[5]	40.9 0.02[2]	45.2 1.45[2]	177.6 0.86[2]
baileyi (Mexico)	17	221.8 0.32[2]	135.0 2.83[5]	76.9 1.97[3]	41.6 0.29[2]	43.6 1.17[2]	171.2 0.16[2]
fuscus (Pacific Northwest)	14	237.1 2.70[5]	137.4 4.19[6]	79.3 5.13[6]	41.9 1.71[2]	49.0 2.76[5]	184.4 2.73[5]
crassodon (Vancouver Island)	7	240.8 3.28[5]	141.6 8.37[6]	79.8 1.32[2]	44.3	45.8 1.80[2]	184.8
nubilus[1] (Great Plains)	19	234.4 2.45[4]	137.4 4.07[6]	77.8 2.56[5]	45.2 4.32[2]	47.5 2.81[5]	181.6 2.20[4]
mogollonensis[1] (Arizona, New Mexico)	11	233.7 4.39[6]	140.6 3.93[6]	81.3 6.31[6]	45.2 2.60[4]	46.4 2.65[4]	182.4 4.41[6]
monstrabilis[1] (Texas, New Mexico, Mexico)	8	234.8 2.63[4]	136.2 3.79[6]	78.8 2.60[4]	45.4 4.23[6]	45.3 2.32[3]	178.8 1.80[2]
youngi[1] (Southern Rockies)	14	240.6 3.19[6]	143.5 4.45[6]	80.7 3.88[6]	46.8 2.98[5]	47.8 3.03[6]	187.6 3.45[6]
irremontus (Northern Rockies)	22	240.9 6.10[6]	140.9 4.13[6]	80.2 2.56[5]	46.3 1.87[3]	46.2 1.51[2]	185.9 2.04[3]

[1] Thought to be extinct.
[2] T—value insignificant.
[3] T—value significant at 0.05.
[4] T—value significant at 0.025.
[5] T—value significant at 0.01.
[6] T—value significant at 0.005.

TABLE 2

Comparison of Some Skull Measurements of the Woodlake Wolf With Those of Adult Male Wolves of Old World Races

	Sample size	Means of measurements (mm), and t-values from statistical comparisons (listed immediately below the means)					
		condylobasal length	Zygomatic width	Postorbital width	Intraorbital width	Upper toothrow length	Upper carnasial length
Woodlake wolf	--	220.0	121.1	37.8	40.9	104.7	25.1
signatus (Spain)	2	225.5	128.0	13.7	41.5	101.0	25.5
chanco (Southeast Asia)	10	217.3 0.35[3]	124.1 0.35[3]	39.9 1.70[3]	44.8 1.05[3]	100.0 1.11[3]	24.4 0.59[3]
pallipes (India, Iraq)	7	202.6 1.40[3]	116.3 1.07[3]	36.8 1.19[3]	37.7 1.24[3]	94.0 2.34[4]	22.6 2.86[5]
lupus (Europe)	6	242.4 2.04[4]	143.7 2.87[5]	42.7 1.77[3]	46.2 1.33[3]	106.8 0.47[3]	26.5 1.67[3]
alba (Russia)	1	244.0	136.0	45.0	48.0	108.0	26.0
hattai[1] (Japan)	1	251.0	151.0	44.0	49.0	115.0	28.0
arabs (Southern Arabia)	?	±183.0	±106.0	--	--	--	19.6[2] 21.0[3]

[1] May be extinct.
[2] Data from Clutton-Brock (1962). N = 7.
[3] T—value insignificant.
[4] T—value significant at 0.05.
[5] T—value significant at 0.025.

DISCUSSION

At the outset of this section, I wish to make clear that there is no way of establishing absolutely the affinities of the Woodlake wolf from the evidence available. The best that can be done is to state the probability of encountering this kind of skull among particular existing races. Also, even though the specimen showed no evident abnormalities, the possibility that this animal was an extremely aberrant individual, such as are known to occur occasionally in nature, cannot be completely ruled out.

According to Grinnell (1933) wolves were not found originally in California west of the Sierra Crest. Young and Goldman (1944) give early written historical records of wolves in this area, but conclude that wolves were extremely scarce, and they do not show them on distribution maps. Also, the reliability of the historical records is subject to question, particularly in view of the common reference to coyotes *(Canis latrans)* as wolves.

Thus, the Woodlake wolf was taken in a region where the original occurrence of wolves was doubtful. Grinnell (1933) established the presence of wolves (*fuscus*) in the northeastern corner of California and in the southeastern desert in eastern San Bernardino County *(youngi)*. The Woodlake specimen does not resemble either of these formerly geographically adjacent races (Table 1).

The wolf has been extirpated over much of the United States, and natural invasion of the Sierra Nevada would involve a journey of hundreds of miles. The nearest wolf population is of the race *baileyi* in Chihuahua, Mexico, some 600 miles away. Individuals of this race occasionally move into the southern portions of the United States. In general body size *baileyi* is similar to the Woodlake specimen, but its skull conformation is at the opposite extreme, being broad, blunt, and robust (Figure 2; Table 1). These differences are readily apparent from visual comparisons, and are even greater than reflected by the statistical difference in the measurements in Table 1. To the north, the nearest wolves are found on Vancouver Island *(crassodon)* and coastal British Columbia *(fuscus)*, about 1,000 miles away. Larrison (1947) reported records of wolves (probably *fuscus*) invading the Cascade Range south to the latitude of Everett, Washington. However, both of these races are very different from the Woodlake wolf (Table 1).

Of the North American wolves, the California specimen is most like the eastern race, *lycaon*, which has a small size and a slender skull conformation. Yet, even it is different statistically in zygomatic breadth and squamosal constriction (Table 1). Furthermore, the nearest remaining animals of this race are around the Great Lakes, approximately 1,700 miles away. It seems incredible that a wolf would or could cross the intervening farmland and mountain chains undetected. Thus, even assuming that the Woodlake wolf were an abnormally slender-skulled member of this race, an artificial introduction would have to be postulated.

Of the Old World wolves, the choice can be quickly limited to two: *signatus* and *chanco*. A few wolves of the race *signatus* still are found in the remote parts of Spain and Portugal, but the museum material

on this race is extremely limited. What evidence there is suggests that the skull of this race is of a broader nature, typical of the genus.

The Woodlake skull is like the race *chanco* of Southeast Asia in nearly every respect. It may be significant that Abe (1930) described the wolves of Korea as a separate race *(coreanus)*, based upon the extreme slenderness of the skull, even more slender than the *chanco* specimens with which Pocock (1935) and Ellerman and Morrison-Scott (1951) lumped them. In fact, the photograph of a Korean wolf skull in Abe's paper is virtually identical to the Woodlake specimen. And, although color of the pelage has little value, Abe's description fits the specimen closely.

When one considers that fair populations of wolves are still present in Korea, that thousands of Americans have been in the country since the beginning of the Korean war, and that wild animals can be purchased live in the market places, the possibility of an introduction from this source is not so remote as one would conclude at first thought.

Thus, the evidence available suggests the following tentative conclusions: (i) the Woodlake wolf is so different from the western races that a natural invasion from these sources is extremely unlikely; (ii) the great distances from similar wolves and the lack of intervening wolf records, as well as the white deposit on the teeth, strongly suggest that the specimen originated from an introduction; (iii) the most similar race in North America is the eastern *lycaon*, but even this race differs significantly in several respects; and (iv) the specimen is most similar to the Southeast Asian *chanco* and particularly the Korean population.

Finally, it should be observed that these conclusions do not rule out the possibility that a small population of wolves exists in the Sierra Nevada, as suggested by Ingles (1963). But if this specimen is from such a population, it appears that it resulted from an introduction. This question cannot be answered until more evidence is available.

SUMMARY

This study compared a wolf taken near Woodlake, California, in 1962 with the world races of wolves in an attempt to ascertain its genetic relationships. The method of study was primarily a statistical comparison of measurements of the Woodlake wolf skull with measurements of the MVZ specimens, and with published data. Final conclusions cannot be reached, but available evidence suggests that this wolf was derived from an introduction by man rather than through a natural invasion of the Sierra Nevada. The specimen is markedly different from western races of wolves. The closest similarities to North American wolves are with the eastern race, *lycaon*, but the extremely slender Woodlake skull is significantly different from this form in both zygomatic breadth and squamosal constriction. It is most like *chanco* of Southeast Asia, and particularly the slender-skulled Korean wolves.

REFERENCES

Abe, Yoshio. 1930. On the Corean [sic] and Japanese wolves. Hiroshima Univ. Jour. Science Series B, Division 1; 1 (3) : 33–37 + one table and 5 plates.

Clutton-Brock, J. 1962. Near Eastern canids and the affinities of the Natufian dogs. Zeitschrift für Tierzüchtung and Zuchtüngsbiologie, 76 (2–3) : 326–333.

Ellerman, J. R., and T. C. S. Morrison-Scott. 1951. Checklist of Palaearctic and Indian mammals. British Mus. (Nat. Hist.). London. 810 p.

Grinnell, Joseph. 1933. A review of the recent mammals of California. Univ. Calif. Publ. in Zoology, 40 (2) : 71–234.

Ingles, Lloyd G. 1963. Status of the wolf in California. Jour. Mammalogy, 44 (1) : 109–110.

Larrison, Earl J. 1947. Miscellaneous distributional notes for Washington. Murrelet, 28 (1) : 11–13.

Pocock, R. I. 1935. The races of *Canis lupus*. Proc. Zool. Soc. London, Part III : 647–686.

Simpson, George G., Anne Roe, and R. C. Lewontin. 1960. Quantitative zoology. Harcourt, Brace and Co., New York. 440 p.

Young, Stanley P., and Edward A. Goldman. 1944. The wolves of North America. Amer. Wildl. Inst., Washington, D.C. 636 p.

Calif. Fish and Game, 53 (3) : 151-161, 1967.

FECUNDITY AND AGE AT MATURITY OF LAKE TROUT, *SALVELINUS NAMAYCUSH* (WALBAUM), IN LAKE TAHOE[1]

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The relationship between fecundity and fork length in inches for 44 female Lake Tahoe lake trout was Y = −9,361.6 + 583.5X, and between fecundity and weight in grams, Y = 17.7 + 1.4X. The number of eggs produced ranged from 919 [17.9-inch fish] to 11,472 [34.0-inch fish]. There was considerable variation in the number of eggs among individual fish relative to both length and weight. A few fish matured in their 5th year of life, and all were mature in their 11th. Lake Tahoe lake trout appear to spawn every year. The spawning season lasts from the middle of September to the first half of November. Over 69% of the lake trout taken by anglers were immature. No changes in angling regulations were recommended.

INTRODUCTION

In July 1960 the California Department of Fish and Game and the Nevada Fish and Game Commission initiated a comprehensive study of Lake Tahoe to determine ways to improve angling. Lake trout are the backbone of the fishery (Cordone and Frantz, 1966*a*) and therefore it was necessary to obtain basic life history information on this species. The purpose of this paper is to present and evaluate data on fecundity, size and age at maturity, and time of spawning. These data plus related information are necessary to help evaluate angling regulations.

Lake trout populations are easily overharvested by a moderate degree of angling pressure when prosecuted on a year-round basis. The extreme vulnerability of immature fish is considered responsible for this (MacKay, 1963). With its year-round season, it was important to evaluate this problem at Lake Tahoe.

METHODS AND MATERIALS

Lake trout fecundity and age at maturity were determined from gonads collected from 1961 through 1963. Data for these years were combined.

The total number of mature or maturing eggs in each pair of ovaries was estimated by the gravimetric method. Sample egg counts were made from approximately one-third of the total weight of both ovaries. Samples were taken from the anterior end of either ovary. Testes were weighed only.

Comparisons of the gravimetric method with actual egg counts for 16 fish showed only slight and random discrepancies. A *t*-test of the paired observations (Li, 1957, p. 96) showed that the differences were not significant at the 5% level ($t = 0.2959$ with 15 d. f.). The differences ranged from an underestimate of 10.3% to an overestimate of 6.1%. Only estimates were used in the analysis.

[1] Submitted for publication February 1967. This study was performed as part of Dingell-Johnson Project California F-21-R and Nevada F-15-R, "Lake Tahoe Fisheries Study", supported by Federal Aid to Fish Restoration funds.
[2] Now with Marine Resources Operations, California Department of Fish and Game.

A random sample of 25 eggs was taken from both ovaries and their diameters measured to the nearest 0.01 mm with an ocular micrometer to determine the mean diameter of mature eggs. Lake trout were measured in fork length to the nearest 0.1 inch, and fish and gonads were weighed to the nearest 0.01 gram.

FECUNDITY

Relationship Between Fecundity and Fork Length

The mean number of eggs produced by 44 fish ranging in length from 16.6 to 34.0 inches and grouped in 2-inch intervals was 3,429 and ranged from 919 (17.9-inch fish) to 11,472 (34.0-inch fish) (Table 1). Extreme variability in fecundity of fish of similar size was evident.

TABLE 1

Relationship Between Fecundity and Length of Lake Tahoe Lake Trout

Fork length (inches)			Number of eggs per fish	
Interval	Mean	Number of fish	Range	Mean
16.0–17.9	17.3	5	919–2,137	1,501
18.0–19.9	18.7	9	1,220–2,363	1,547
20.0–21.9	21.2	11	1,477–3,627	2,557
22.0–23.9	22.8	10	1,749–4,274	3,384
24.0–25.9	24.7	3	5,162–6,521	5,770
26.0–27.9	26.8	3	3,704–7,891	6,276
29.3		1	-	8,576
30.7		1	-	9,401
34.0		1	-	11,472
	Total	44	Grand mean	3,429

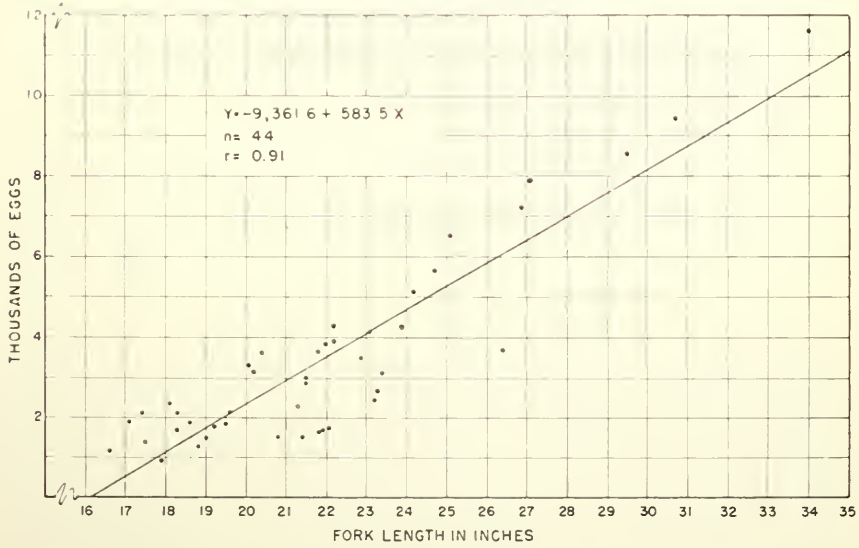

FIGURE 1—Relationship between fork length and fecundity of female Lake Tahoe lake trout.

Southern Lake Michigan lake trout exhibited similar variations (Eschmeyer, 1955).

The linear regression $Y = -9{,}361.6 + 583.5X$ (where Y is the estimated number of eggs and X is the fork length in inches) describes the relationship between fecundity and length (Figure 1). The correlation coefficient was 0.91. The slope of the line shows an increase of about 584 eggs per 1-inch increase in length.

Relationship Between Fecundity and Weight

The equation $Y = 17.7 + 1.4X$ describes the relationship between fecundity and weight (Figure 2). The correlation coefficient equals 0.94.

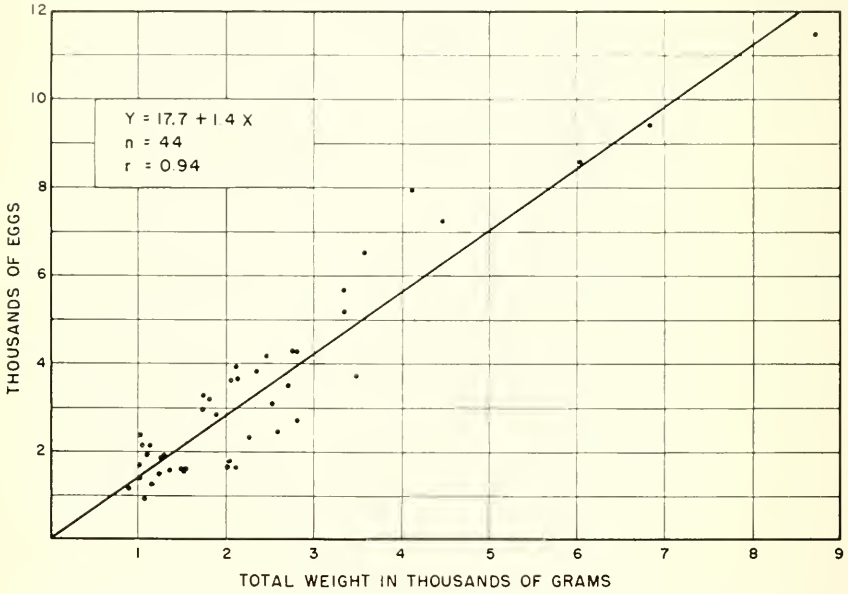

FIGURE 2—Relationship between total weight and fecundity of female Lake Tahoe lake trout.

Fecundity ranged from 919 eggs at a weight of 1,089 grams to 11,472 at 8,709 grams. The mean number of eggs produced by fish grouped in 500-gram intervals increased from 1,162 to 11,472 but the ranges overlapped considerably due to individual variations in fecundity (Table 2). The number of eggs produced per 100 grams of fish was 141.7, which approximates the slope of the calculated line.

Relationship Between Fecundity and Age

The ages of 36 fish collected for the fecundity study were determined previously (Hanson and Cordone, 1967). These fish ranged from age group VI to age group XII. As with length and weight, fish of the same size varied greatly in fecundity (Table 3). The mean number of eggs increased from 1,866 for age VI fish to 9,401 for a single age XI fish (one age XII fish contained 8,576 eggs).

TABLE 2

Relationship Between Fecundity and Weight of Lake Tahoe Lake Trout

Weight (grams)		Number of fish	Number of eggs per fish		Number of eggs per 100 grams of fish	
Interval	Mean		Range	Mean	Range	Mean
902.6	--	1	--	1,162.0	--	128.7
1,000–1,499	1,184.2	13	919–2,363	1,708.5	84.4–228.3	147.0
1,500–1,999	1,715.3	6	1,460–3,273	2,541.8	94.4–186.9	145.9
2,000–2,499	2,183.3	9	1,666–3,898	2,939.4	78.1–182.9	133.5
2,500–2,999	2,707.9	6	2,415–4,274	3,371.5	93.1–154.4	124.1
3,000–3,499	3,401.9	3	3,704–5,626	4,830.7	106.0–167.6	142.5
3,583.4	--	1	--	6,521.0	--	182.0
4,000–4,499	4,297.8	2	7,233–7,891	7,562.0	161.9–191.2	176.5
6,032.8		1	--	8,576.0	--	142.2
6,849.2		1	--	9,401.0	--	137.3
8,708.9		1	--	11,472.0	--	131.7
	Total	44		Grand mean		141.7

AGE AND SIZE AT MATURITY

We separated fish that would spawn in the year of capture from those that would not and refer to them as mature and immature, respectively. Some immature fish actually could have been mature fish which were not going to spawn in the year of capture. This phenomenon has been described for lake trout from other lakes. However, evidence presented later leads us to believe that mature Lake Tahoe lake trout ordinarily spawn every year.

Analysis of census data and examination of angler-caught fish revealed that mature lake trout are less vulnerable to fishing in October than in other months. Therefore, October fish were eliminated in the analysis of the percentage of mature fish at different ages.

TABLE 3

Relationship Between Fecundity and Age of Lake Tahoe Lake Trout

Age group	Number of fish	Fork length (inches)		Weight (grams)		Number of eggs per fish	
		Range	Mean	Range	Mean	Range	Mean
VI	11	17.1–20.2	18.5	1,016.0–1,823.4	1,222.6	919–3,164	1,865.8
VII	11	16.6–23.2	20.7	902.6–2,766.9	1,879.1	1,220–4,774	2,482.4
VIII	5	20.8–22.9	21.9	1,505.9–2,721.5	2,050.2	1,540–3,898	2,715.6
IX	3	21.8–27.1	23.6	2,032.0–4,127.7	2,771.4	1,632–7,891	4,383.3
X	4	23.1–24.7	23.8	2,449.4–3,356.6	2,789.6	3,102–5,626	4,283.0
XI	1	--	30.7	--	6,849.2	--	9,401.0
XII	1	--	29.3	--	6,032.8	--	8,576.0

Percentages of mature male lake trout in each age group tended to be slightly higher than females at the same age (Table 4). Three

TABLE 4

Relationship Between Age and State of Maturity of Lake Tahoe Lake Trout

		Age group												
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Males	Number mature	0	0	0	2	9	18	24	30	11	5	4	3	0	2
	Mean fork length				17.8	17.7	18.6	20.7	22.8	23.4	24.2	29.2	29.5		29.8
	Number immature	1	3	15	22	50	54	25	5	5	0	1	0	0	0
	Mean fork length	4.8	8.6	10.3	13.0	15.7	17.2	18.5	19.0	22.5		22.3			
	Percentage mature	0.0	0.0	0.0	8.3	15.3	25.0	49.0	85.7	68.8	100.0	80.0	100.0		100.0
Females	Number mature	0	0	0	1	1	22	17	19	4	9	1	1	0	0
	Mean fork length				21.7	18.9	19.1	20.7	22.1	24.1	25.8	30.7	32.7		
	Number immature	1	1	9	19	37	46	28	13	2	2	0	0	0	0
	Mean fork length	3.4	7.0	9.9	14.0	15.3	17.3	18.4	18.8	21.6	23.2				
	Percentage mature	0.0	0.0	0.0	5.0	9.8	32.4	37.8	59.4	66.7	81.8	100.0	100.0		

fish (two males and one female) in their 5th year of life (age group IV) were mature. However, these were exceptionally large and fast growing individuals, measuring 17.8, 17.9, and 24.7 inches. For both sexes, 50% of the individuals in their 8th year were mature (Table 4). All males matured by their 10th year, and all females by their 11th year.

Lake Tahoe lake trout mature at a younger age than lake trout in most other lakes; however, these mature fish are extremely large for their age. In several Canadian lakes, lake trout did not mature until their 6th year (Martin, 1952; McCrimmon, 1956; Cuerrier and Schultz, 1957; Rawson, 1961), and not until their 14th year in Great Bear Lake (Miller and Kennedy, 1948). However, lake trout mature in their 5th year in Great Slave Lake (Kennedy, 1954) and Lake Opeongo (Fry, 1949).

Mature male lake trout ranged from 13.2 to 34.4 inches and mature females from 16.6 to 32.7 inches (Table 5). Although the smallest mature female was 2.4 inches longer than the smallest mature male,

TABLE 5

Length Frequency Distribution of Lake Tahoe Lake Trout by Sex and State of Maturity

Fork length* (inches)	Males			Females		
	Immature	Mature	Percentage mature	Immature	Mature	Percentage mature
7.0–7.9	2	0	0.0	1	0	0.0
8.0–8.9	3	0	0.0	0	0	0.0
9.0–9.9	8	0	0.0	8	0	0.0
10.0–10.9	4	0	0.0	2	0	0.0
11.0–11.9	11	0	0.0	1	0	0.0
12.0–12.9	6	0	0.0	13	0	0.0
13.0–13.9	11	1	8.3	8	0	0.0
14.0–14.9	20	1	4.8	21	0	0.0
15.0–15.9	32	1	3.0	25	0	0.0
16.0–16.9	37	7	15.9	27	1	3.6
17.0–17.9	38	17	30.9	46	8	14.8
18.0–18.9	26	13	33.3	31	14	31.1
19.0–19.9	18	16	47.1	19	16	45.7
20.0–20.9	7	11	61.1	9	8	47.1
21.0–21.9	12	15	55.6	6	11	64.7
22.0–22.9	3	11	78.6	5	15	75.0
23.0–23.9	3	11	78.6	1	14	93.3
24.0–24.9	1	17	94.4	1	5	83.3
25.0–25.9	0	10	100.0	0	7	100.0
26.0–26.9	0	6	100.0	0	0	--
27.0–27.9	0	5	100.0	0	2	100.0
28.0–28.9	0	2	100.0	0	0	--
29.0–29.9	0	2	100.0	0	1	100.0
30.0–30.9	0	0	--	0	2	100.0
31.0–31.9	0	0	--	0	0	--
32.0–32.9	0	2	100.0	0	1	100.0
33.0–33.9	0	1	100.0	0	0	--
34.0–34.9	0	1	100.0	0	0	--

* Two immature fish smaller than 7.0 inches not shown.

both sexes were 100% mature at nearly the same size (males at 24.1 inches and females at 24.6). Almost half of the females were mature in the 20.0- to 20.9-inch interval, and half of the males in the 19.0- to 19.9-inch interval. Eschmeyer (1955) also found males maturing at a smaller size than females in southern Lake Michigan.

Sizes at first maturity reported for Great Bear Lake (Miller and Kennedy, 1948), Great Slave Lake (Kennedy, 1954), and Waterton Lakes (Cuerrier and Schultz, 1957), Canada, were similar to Lake Tahoe. In contrast, Martin (1952) found large numbers of lake trout mature at 12 inches and the majority at 16 inches in Lake Louisa and Redrock Lake, Ontario, respectively. Royce (1951) found none maturing until they reached 26 to 30 inches in Seneca Lake, New York.

An interesting aspect of these data is the apparent decrease in percentage of mature males at ages IX and XI (Table 4). Fry (1949) reported a similar condition occurring for both sexes in Lake Opeongo and believed that this portion of the population does not spawn every year. Various other authors have reported that lake trout do not spawn every year (Kennedy, 1954; Cuerrier and Schultz, 1957; Rawson, 1961). In Great Bear Lake they probably spawn only every third year or, at most, every second (Miller and Kennedy, 1948). Lakes in which lake trout spawn less than once a year are typically northern, oligotrophic lakes, and Great Bear Lake is an extreme example of this.

Miller (1951) found what he believed to be mature female Lake Tahoe lake trout with eggs that would not ripen in that year. He suggests that these fish would fail to spawn, but does not give their lengths. Although the evidence isn't conclusive, we believe that Lake Tahoe lake trout ordinarily spawn every year. The five immature fish in age group IX and the one in age group XI were small for their age (Table 4), and probably were slow growing and late maturing indi-

TABLE 6

Weight of Ovaries as Percentage of Total Body Weight and Egg Diameter for Mature Female Lake Tahoe Lake Trout

Date of collection	Number of fish	Mean egg diameter (mm)	Percentage weight of ovaries
June 1–15	6	2.74	3.6
16–30	0	--	--
July 1–15	0	--	--
16–31	1	2.78	3.7
August 1–15	8	4.08	6.5
16–31	6	4.54	8.0
September 1–15	5	4.91	8.0
16–30	8	5.35	12.4
October 1–15	3	5.35	14.7
16–31	3	5.65	17.8
November 1–15	3	5.80	17.6

viduals. (However, Martin (1966) reported that slow growing lake trout matured at a smaller size and younger age.) Also, the percentage of mature females increased with age, reaching 100% at age XI, indicating that at this age and older they spawn every year. Eschmeyer (1955) found no evidence that mature lake trout did not spawn every year in southern Lake Michigan.

SPAWNING SEASON

The exact period of spawning for Lake Tahoe lake trout is not known. We could not locate spawning beds and relatively few ripe fish were captured. However, it appears that spawning begins in September and peaks in October.

In September the mean length of angler-caught fish begins to decline and reaches an annual low in October (Cordone and Frantz, 1966*a*). Moreover, the percentage of mature fish taken by anglers declines sharply at this time. These changes may reflect reduced availability of mature fish to the angler because the fish are congregating on the spawning grounds and are not actively foraging.

Progression of the spawning season was followed by plotting changes in egg diameters and weight of the ovaries relative to total weight of mature fish taken from June through November (Table 6 and Figure 3). During this period, the mean egg diameter increased from 2.74 to 5.80 mm while the mean weight of the ovaries relative to total body weight increased from 3.6 to 17.6%. Relative weights of the testes also increased during this period.

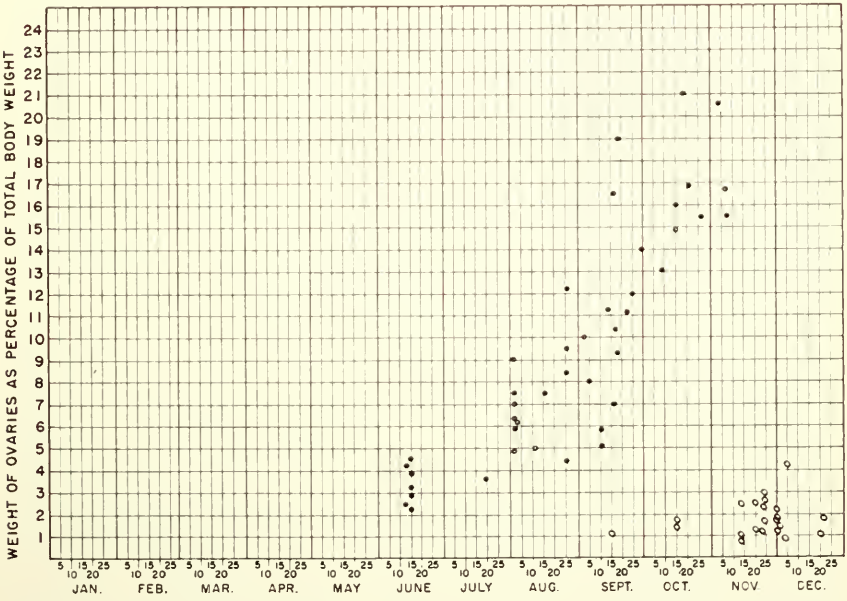

FIGURE 3—Seasonal change in relative weight of ovaries of mature female Lake Tahoe lake trout. Closed circles are ripe fish and open circles spent fish.

We collected no mature females after November 8. However, a ripe female was taken in a gill net on January 24, 1956 (Ray Corlett, unpublished data).[3] Mature males were taken as late as January 27. Most of the spent females were taken in the last half of November, with one taken as early as September 15 (Figure 3).

Hence, it appears that the spawning season for Lake Tahoe lake trout covers at least the period from the middle of September through the first half of November, with an occasional fish spawning as late as the last half of January. This rather protracted spawning season conforms to Royce's (1951) statement that the length of the spawning season increases in large lakes (Lake Tahoe is 123,300 surface acres), and corresponds to the one-month spawning season reported for the Great Lakes by Van Oosten (1934). However, in Lac la Ronge (352,000 surface acres) the spawning season is restricted to less than a week (Rawson, 1961).

DISCUSSION

Comparisons of length frequencies of angler-caught fish and the percentages of immature fish in corresponding length intervals revealed that about 69% of all lake trout taken were immature. The highest percentages of immature fish were caught from June through October. These months accounted for approximately 56% of the total catch (Cordone and Frantz, 1966*b*). Percentages of immature fish ranged from 59.4 in February to 82.3 in October during the peak of the spawning season. Further analysis of the length frequencies indicated that the higher percentages of immature fish in the summer and fall months were due to a decrease in the vulnerability of larger, mature fish rather than in increase in the vulnerability of smaller, immature fish. This contrasts with information presented by Martin (1954), who demonstrated that winter fishing in Algonquin Park lakes results in greater exploitation of small, immature fish than summer fishing.

The harvest rate of immature fish has important management implications. The 69% exploitation of immature lake trout in Tahoe appears quite excessive. Long-term studies in Algonquin Park by Martin (1966) showed that higher percentages of immature lake trout were harvested from piscivorous populations than from planktonivorous ones; approximately 45% compared to 15%, respectively However, while not minimizing the importance of high spawning escapement, Martin does point out that size of spawning stock may not be an important factor in year-class strength. Fry and Kennedy (1937) reported that in Lake Opeongo, Algonquin Park, about two-thirds of the lake trout were harvested in July and August and that about 50% of these were immature. They believed that, ". . . if the fishery is exploited without control it is very likely to be faced with the prospect of depletion." It is difficult to make meaningful comparisons between Tahoe and these small Canadian lakes. However, the percentage harvest of immature Tahoe lake trout is so high by comparison that we were concerned about overharvest of the population under the present year-round season. This, however, does not appear to be the case.

Cordone and Frantz (1966*a*) analyzed trends in the lake trout fishery, including some historical data covering a 17-year span. No

[3] Nevada Fish and Game Commission, Dingell-Johnson Project F-4-R, monthly report for January 1956.

significant historical changes in the catch per hour or mean weight of lake trout could be detected. Unpublished results of a lake trout tagging study at Tahoe indicated high exploitation rates for immature lake trout, with much reduced rates for the larger, mature fish. The low vulnerability of these fish is probably related to a combination of factors. One possibility is the congregation and reduced feeding of ripe fish just before and during the spawning period. Another involves the prevalence of precipitous slopes in Tahoe which are virtually unfishable with conventional trolling gear and which may provide refuge for large lake trout. In any event, enhanced survival of the larger, mature trout appears to provide adequate spawning escapement and no changes in angling regulations are recommended.

SUMMARY

The relationships between fecundity and fork length and fecundity and total weight are described by the equations $Y = -9{,}361.6 + 583.5X$ and $Y = 17.7 + 1.4X$, respectively. There was considerable variation among individual fish in the number of eggs produced relative to length, weight, and age. The relationship between fecundity and weight appeared strongest. The mean number of eggs produced by 44 fish was 3,429 and ranged from 919 for a 17.9-inch, 1,089-gram fish, to 11,472 for a 34.0-inch, 8,709-gram fish.

A few lake trout mature in their 5th year of life and all were mature by their 11th. Mature males ranged from 13.2 to 34.4 inches FL and mature females 16.6 to 32.7 inches. We found no evidence that Lake Tahoe lake trout do not spawn every year.

The spawning season lasts from about the middle of September through the first half of November.

Immature fish are extremely vulnerable throughout the year, and make up over 69% of the total catch. No changes in regulations are recommended.

ACKNOWLEDGMENTS

We wish to express our thanks to Alnio J. Cordone and Robert F. Elwell of the California Department of Fish and Game for their assistance in the preparation of this report. We also wish to acknowledge Cliffa E. Corson for drawing the figures.

REFERENCES

Cordone, Alnio J., and Ted C. Frantz. 1966*a*. The Lake Tahoe sport fishery. Calif. Fish and Game, 52 (4) : 240–274.

———. 1966*b*. The Lake Tahoe sport fishery—supplementary report. Calif. Dept. Fish and Game, Inland Fish Admin. Rept., (66-14) : 94 p. (Mimeo.)

Cuerrier, J. P., and F. H. Schultz. 1957. Studies of lake trout and common whitefish in Waterton Lakes, Waterton Lakes National Park, Alberta. Canadian Wildl. Serv., Wildl. Mgmt. Bull., Ser. 3, No. 5, 41 p.

Eschmeyer, Paul H. 1955. The reproduction of lake trout in southern Lake Superior. Trans. Amer. Fish. Soc., 84 (1954) : 47–74.

Fry, F. E. J. 1949. Statistics of a lake trout fishery. Biometrics, 5 (1) : 27–67.

Fry, F. E. J., and W. A. Kennedy. 1937. Report on the 1936 lake trout investigation, Lake Opeongo, Ontario. Univ. Toronto Stud., Biol. Ser. 42, Publ. Ont. Fish. Res. Lab., No. 54, 20 p.

Hanson, Jack A., and Almo J. Cordone. 1967. Age and growth of the lake trout, *Salvelinus namaycush* (Walbaum), in Lake Tahoe, Calif. Fish and Game, 53 (2) : 68–87.

Kennedy, W. A. 1954. Growth, maturity and mortality in the relatively unexploited lake trout, *Cristivomer namaycush*, of Great Slave Lake. Jour. Fish. Res. Bd. Canada, 11 (6) : 827–852.

Li, Jerome C. R. 1957. Introduction to statistical inference. Edwards Bros., Inc., Ann Arbor, Mich. 553 p.

Martin, Nigel V. 1952. A study of the lake trout, *Salvelinus namaycush*, in two Algonquin Park, Ontario, lakes. Trans. Amer. Fish. Soc., 81 (1951) : 111–137.

———. 1954. Catch and winter food of lake trout in certain Algonquin Park lakes. Jour. Fish. Res. Bd. Canada, 11 (1) : 5–10.

———. 1966. The significance of food habits in the biology, exploitation, and management of Algonquin Park, Ontario, lake trout. Trans. Amer. Fish. Soc., 95 (4) : 415–422.

McCrimmon, H. R. 1956. Fishing in Lake Simcoe. Ontario Dept. Lands and Forests, 137 p.

MacKay, H. H. 1963. Fishes of Ontario. Ontario Dept. of Lands and Forests. The Bryant Press Limited, Toronto, 300 p.

Miller, R. B., and W. A. Kennedy. 1948. Observations on the lake trout of Great Bear Lake. Jour. Fish. Res. Bd. Canada, 7 (4) : 176–189.

Miller, Richard Gordon. 1951. The natural history of Lake Tahoe Fishes. Stanford Univ., Ph.D. Dissertation, 160 p.

Rawson, D. S. 1961. The lake trout of Lac la Ronge, Saskatchewan. Jour. Fish. Res. Bd. Canada, 18 (3) : 423–462.

Royce, William F. 1951. Breeding habits of lake trout in New York. U. S. Fish and Wildl. Serv., Fish. Bull., 52 (59) : 59–76.

Van Oosten, John. 1934. The value of questionnaires in commercial fisheries regulations and surveys. Trans. Amer. Fish. Soc., 64 : 107–117.

Calif. Fish and Game, 53 (3) : 165-173. 1967.

DISTRIBUTION, SIZE COMPOSITION, AND RELATIVE ABUNDANCE OF THE LAHONTAN SPECKLED DACE, *RHINICHTHYS OSCULUS ROBUSTUS* (RUTTER), IN LAKE TAHOE[1]

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Aspects of the life history of the Lahontan speckled dace in Lake Tahoe were studied. Data on distribution, activity patterns, size composition, and relative abundance are presented. The most effective methods for collecting dace were shoreline rotenoning and minnow trapping. The minnow trap catch rates indicate that dace occur primarily in the rocky benthic area of the littoral zone at depths less than 25 feet, but are occasionally found to depths of 200 feet. Dace were most active during the summer and early fall, when water temperatures are warmest, becoming relatively dormant when temperatures dropped below approximately 50 F. The mean size of dace collected was 2.1 inches fork length, with a maximum size of 3.5 inches. Length frequency analysis indicated that approximately six age groups are represented in the collections.

INTRODUCTION

The Lahontan speckled dace was originally described as *Agosia robusta* by Rutter (1903). The type locality is Prosser Creek, Nevada County, California. This subspecies occurs in the Lahontan Basin of Nevada and California. Kimsey (1950) also reported it from waters tributary to the Sacramento River drainage, into which it may have been introduced.

Little is known of the life history of the speckled dace in Lake Tahoe. Miller (1951) presented data on dace distribution and food habits. Evans (1966) and Hopkirk and Behnke (1966) reported natural intergeneric hybridization of dace with other Tahoe cyprinids. This report deals primarily with distribution, activity patterns, size composition, and relative abundance of Lake Tahoe speckled dace. It is one of a series of reports on the life histories of Tahoe fishes. These are based on investigations conducted by the cooperative Lake Tahoe Fisheries Study initiated by the California Department of Fish and Game and Nevada Fish and Game Commission on July 1, 1960. McGauhey et. al (1963) present a detailed description of Lake Tahoe.

METHODS

Shoreline rotenoning and minnow trapping were the most effective methods for sampling speckled dace in Lake Tahoe. Sixty-six percent of the 2,250 dace sampled were taken with rotenone, and 17% by minnow traps. The remaining 17% were taken by seines and sled and otter trawls. None were captured in bottom or open-water gill nets, although mesh sizes used were as small as $\frac{5}{8}$-inch stretch measure.

All dace were measured to the nearest 0.1 inch, FL.

[1] Submitted for publication February 1967. This work was performed as part of Dingell-Johnson Project California F-21-R and Nevada F-15-R, "Lake Tahoe Fisheries Study", supported in part by Federal Aid to Fish Restoration funds.
[2] Now with Region 2, California Department of Fish and Game.

Shoreline Rotenoning

Shoreline areas of the lake were rotenoned in August 1963, August and September 1964, July 1965, and March 1966. In 1963 sampling areas were located at Eagle Point, Sugar Pine Point, Dollar Point, Crystal Bay, Secret Harbor, and Zephyr Cove (see Weidlein, Cordone, and Frantz (1965) for a map of the locations). In 1964 these areas and one in Emerald Bay were rotenoned. Only the Sugar Pine Point area was rotenoned in 1965. These areas were approximately 50 feet long and 20 feet wide, with depths to about 4 feet. In 1966 an area near Cave Rock was rotenoned. Maximum depth here was about 15 feet.

When rotenoning, the areas usually were first enclosed with a seine to reduce the numbers of fish escaping, and then sprayed with Pronoxfish. Care was taken to recover as many fish as possible. This method seemed to be satisfactory in randomly sampling all sizes of dace. However, it did not provide accurate quantitative catch data for comparisons between samples.

Minnow Trapping

Two types of minnow traps provided the only quantitative catch data for speckled dace. One type was a small, cylindrical, commercially-made trap, 17 inches long and $8\frac{1}{2}$ inches in diameter, with 1-inch diameter fykes at each end. The covering material was $\frac{1}{4}$-inch galvanized screening. These were fished monthly, from March 1962 through May 1964, during daylight hours at the Cave Rock boat launching ramp. The traps were generally fished on the bottom in 8 to 12 feet of water, and canned dog food was used as bait.

The second type was a large rectangular trap, 36 inches long on the side and 18 inches square on the ends, with $1\frac{1}{2}$-inch square fykes on each end. The covering material was $\frac{1}{2}$-inch galvanized screening. These traps were fished on the bottom in conjunction with the bottom gill net sets, at depths of 25, 100, 300, and 500 feet, in selected locations around the lake. Usually one, but as many as three, depth series, each in a different location, were sampled monthly from July 1963 through June 1964. Most sets were fished overnight for an average duration of 20 hours; however, some were unavoidably fished as long as 3 days. Bread and cheese were used as bait.

Other Methods

The sled trawl was quite effective in sampling dace in shallow water. Unfortunately, lack of time did not permit more extensive use of this gear. It is described by Linn and Frantz (1965). The larger otter trawl took few dace, probably because it was fished in relatively deep water. This gear and its operation will be described by the author in a forthcoming publication.

DISTRIBUTION

Spatial Distribution

Lahontan speckled dace appear to be most abundant in Tahoe's littoral zone at depths less than 25 feet, below which numbers decrease rapidly with depth. Moreover, the data indicate that they prefer the rocky areas of this zone, at least during daylight hours.

The small "commercial" minnow traps set in rocky habitat at Cave Rock were consistently more successful than the larger traps associ-

TABLE 1

Catch Per Hour of Lahontan Speckled Dace in Commercial Minnow Traps, and Mean Surface Water Temperatures, at Cave Rock, Lake Tahoe, From March 1962 Through May 1964

Month	1962		1963		1964		Mean	
	Catch per hour	Surface temperature*	Catch per hour	Surface temperature*	Catch per hour	Surface temperature*	Catch per hour	Surface temperature*
January	--	--	--	--	0.7	45	0.7	45
February	--	--	2.0	13	0.0	42	1.0	42½
March	0.2	40	--	--	0.0	42	0.1	41
April	0.3	49½	0.0	44	0.5	44	0.3	46
May	0.8	50½	0.0	47½	0.2	47	0.3	48½
June	0.0	61	0.4	56½	--	--	0.2	59
July	2.0	65	0.5	60	--	--	1.2	62½
August	10.8	66	7.0	65	--	--	8.9	65½
September	10.3	62	1.9	62½	--	--	6.1	62
October	7.5	56	3.6	57	--	--	5.6	56½
November	0.2	50½	0.6	46	--	--	0.3	48
December	1.5	--	0.1	47	--	--	0.8	47
Mean	**2.05**	**55.6**	**1.22**	**52.8**	**0.31**	**44.0**	**1.43**	**52.0**

* Temperatures recorded in degrees Fahrenheit and rounded to nearest half degree.

ated with bottom gill nets set usually on sand and mud substrates in deeper water. The catches of the two types of traps are not, however, directly comparable, since they differed in size and construction, type of bait used, and duration fished.

Catches in the larger traps, although small, decreased significantly with depth. From July 1963 through June 1964, catches at the 25-foot depth totaled 108 dace for a mean catch per hour of 0.27. Identical traps set in 100 feet of water took only one dace during this period, while those in 300 and 500 feet failed to take dace.

Otter trawling from October 1963 through September 1964 took speckled dace on three separate occasions at 100 feet and once at 200 feet at the south end of the lake. The latter is a depth record for dace in Tahoe. The previous record of 100 feet was reported by Miller (1951). No dace were taken in trawls at Agate Bay during this period.

During summer months, dace were observed in a number of Tahoe tributaries and probably exist in all of them, at least in their lower reaches. Murphy (1963) conducted a short-term study in late summer of trout survival in a 295-foot screened section of lower Taylor Creek. Of the fish removed from the study section, 86% were dace. Murphy noted enormous numbers of small dace moving toward Lake Tahoe at the end of August.

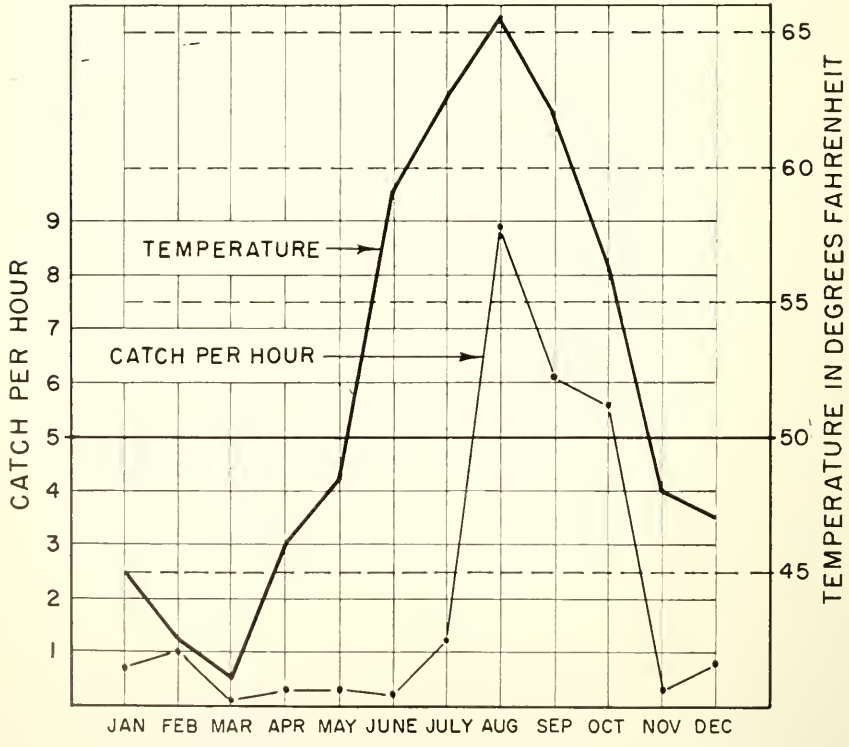

FIGURE 1—Mean catch per haur af Lahontan speckled dace in "cammercial" minnaw traps, and mean surface water temperatures at Cave Rock, Lake Tahae, from March 1962 through March 1964.

Seasonal Distribution

Seasonal changes in the minnow trap catches at Cave Rock were quite pronounced. Large catches were made during the late summer and early fall, but dropped to uniformly low levels throughout the rest of the year (Figure 1, Table 1). Significantly, catches in the larger traps in 25 feet were confined entirely to the summer and early fall period. Furthermore, dace were taken by rotenone at Cave Rock at depths less than 15 feet in March 1966, indicating that at least some dace remain in shallow water during the winter. Therefore, changes in minnow trap catch rates were probably the result of seasonal changes in activity.

Mean monthly catches at Cave Rock correspond well with the mean surface water temperatures there. Largest catches, averaging 8.9 dace per hour, occurred during August, when the water temperatures were highest (65½ F). Catch rates were much lower from November through May, when temperatures fell below approximately 50 F. Catches remained low even into June and July, when temperatures rose to 59

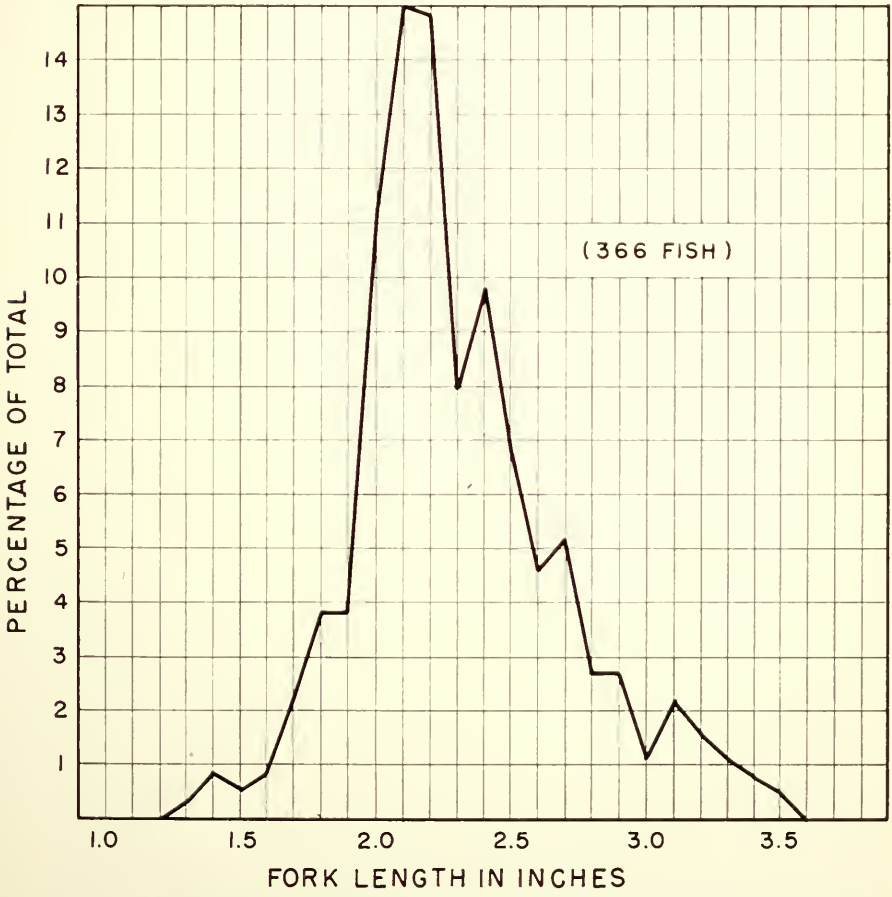

FIGURE 2—Length frequency of Lahontan speckled dace taken by minnow traps at Lake Tahoe from 1962 through 1965.

and 62½ F, respectively. However, the low catch rates during this period may be due to spawning activity. Miller (1951) and La Rivers (1962) suggest that spawning occurs about this time.

SIZE COMPOSITION

Length frequency data for dace taken in both types of minnow traps (Figure 2) indicate that dace less than 2.1 inches were not fully vulnerable to trapping. Only 23.0% of the dace sampled with traps were smaller than 2.1 inches, whereas 72.3% of those taken with rotenone were of that size (1966 sample not included) (Figure 3). There-

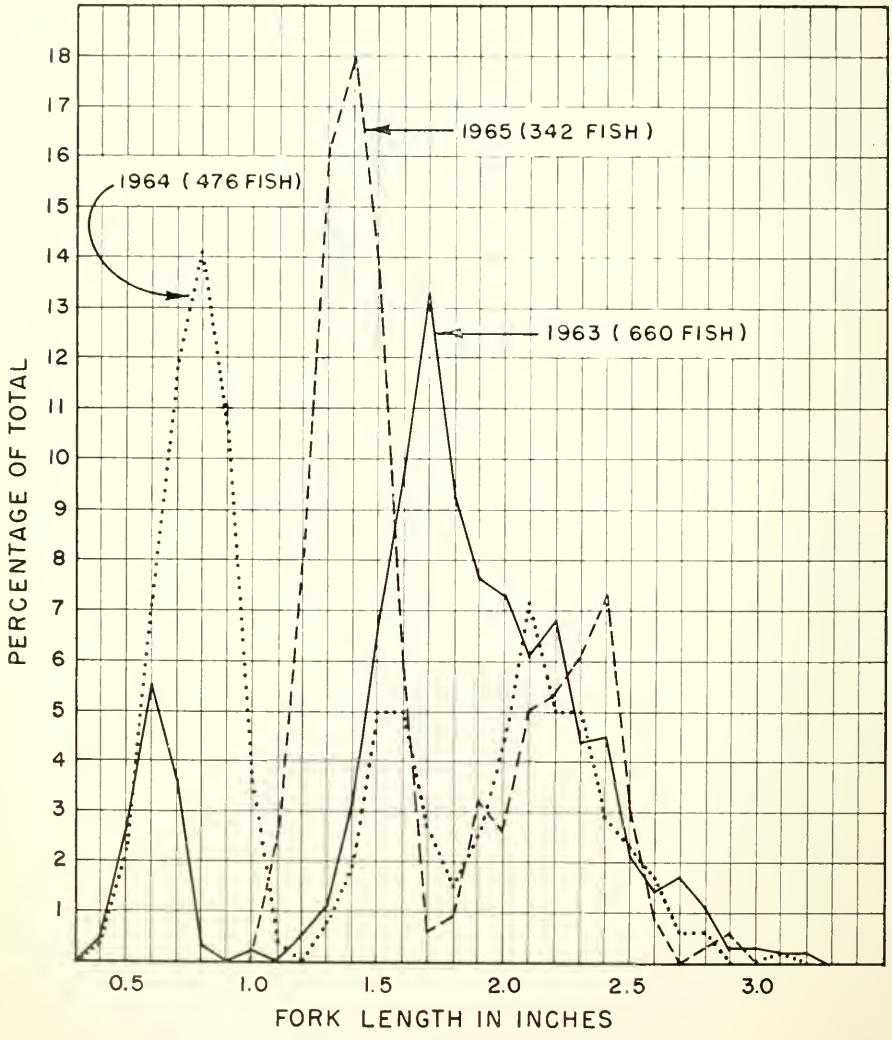

FIGURE 3—Length frequency of Lahontan speckled dace taken by rotenone in Lake Tahoe during August 15 and 16, 1963; August 20 and 21 and September 2 and 3, 1964; and July 19, 1965.

fore, minnow trap catches may not accurately reflect the distribution, movements, or activity of the smaller dace.

However, the descending limbs of the length frequencies appear to be similar, indicating that both methods were equally selective to the larger fish. The largest dace taken by the two methods were 3.5 and 3.2 inches for minnow trapping and rotenoning, respectively.

Length frequencies of the rotenone samples indicate that the maximum size obtained by early September of the first year of life is about 1.1 inches, with a modal length of approximately 0.8 inches. The mean length obtained by early September of the second year appears to be about 1.7 inches. In all, it appears that about five or six age groups are represented in these collections.

Year-class strength appears to vary considerably. What is assumed to be the 1963 year class seems to be very weak, lacking the larger, faster-growing individuals of the 1964 year class. The former can be identified in all of the collections, although in the 1965 collection it is nearly obliterated by the stronger 1962 year class.

RELATIVE ABUNDANCE

No sampling method used was equally selective for all of Tahoe's fishes. Selectivity varied not only with species and fish size, but also with type of habitat and time of day fished. Rotenoning and sled trawling were the only methods which may have randomly sampled the dace populations. Both, however, were definitely selective to the smaller and less mobile fish species. In spite of these limitations, a rough idea of the relative abundance of dace and other species in the littoral zone can be obtained from rotenone and sled trawl samples.

Speckled dace were the most abundant species in the shoreline rotenone samples, but their percentages varied from year to year. In 1963, 64.6% of the fish taken were dace, compared with 74.7% in 1964, 81.2% in 1965, and 33.3% in 1966. Overall, 70.1% of the fish were dace, 14.7% Lahontan redside (*Richardsonius egregius*), 7.1% Piute sculpin (*Cottus beldingii*), 3.9% Tahoe sucker (*Catostomus tahoensis*), 3.2% rainbow trout (*Salmo gairdneri*), and the remaining 1.0% tui chub (*Siphateles bicolor*), brown trout (*Salmo trutta*), mountain whitefish (*Prosopium williamsoni*), and eastern brook trout (*Salvelinus fontinalis*).

Sled-trawl catches in slightly deeper water had substantially different species compositions than the rotenone samples. Here dace appeared less numerous. In the combined catches of four trawls (made on September 5, 1963; April 1, 1966; and May 2 and 20, 1966), 28.3% of the fish were dace. Piute sculpin comprised 31.9%; small cyprinids (probably tui chub and Lahontan redside), 17.7%; mountain whitefish, 11.1%; tui chub, 6.1%; Tahoe sucker, 2.2%; Lahontan redside, 1.9%; and kokanee salmon (*Oncorhynchus nerka*), 0.8%.

DISCUSSION

Although the speckled dace is most abundant in the rocky shoreline habitat in Lake Tahoe, it is not entirely restricted to this zone. Evans (1966) collected large numbers of dace fry in a shallow, marshy area off Lake Forest in midsummer. This appears to be a popular nursery

area for dace, redsides, chubs, and suckers. However, such areas are insignificant in size compared with the typical shore line of sand and rock. Large aggregations of dace fry are also common in very shallow water over sand and rock substrates.

As the most abundant species in the littoral zone, dace assume an important role in the lake's ecology. Miller (1951) found that dace fed largely on bottom organisms in Lake Tahoe, and assumed that they compete with chubs, redsides, sculpin, and whitefish for food. About 81% of the stomachs contained bottom organisms, while only 22% contained plankton. By volume, virtually all the contents were benthic, with plankton contributing only trace amounts. Important benthic forms were snails and dipteran larvae, followed by caddisfly larvae, beetles, mayfly nymphs, and water mites. Based on the collections reported here, dace may also compete with small suckers and rainbow trout fry. Evans (1966) believes that since dace rely so heavily on the cover afforded by the rocky bottoms of the littoral zone, they do not compete with the more widely ranging redsides and chubs. Data presented by Calhoun (1944) for Upper Blue Lake, Alpine County, California, demonstrated that speckled dace probably compete severely for food with fingerling Lahontan cutthroat trout (*Salmo clarkii henshawi*). Predation on fishes by the dace is apparently restricted to eating eggs of other species. Miller observed dace rooting out the eggs of spawning redsides and suckers.

Speckled dace are unimportant in Tahoe game fish food chains, a reflection of their secretive habits and preference for rocky substrates. Miller (1951) found none in the stomachs of 191 lake trout and 80 rainbow trout. He also did not locate any in the stomachs of nongame fishes. Only 2 dace were found in 1,391 lake trout stomachs, with 4 recorded from 938 rainbow trout stomachs, and none from 98 brown trout stomachs (Lake Tahoe Fisheries Study, unpubl. data). Concerning the diet of Lahontan cutthroat, Calhoun (1944) remarked, "The almost complete absence from the stomachs of the small minnow (*Rhinichthys osculo*) which is abundant in the shallows around the lake came as a considerable surprise." Because dace prefer the marginal shallows, Miller believes they fall prey to various avian and reptilian predators, and thus may act as a buffer to other fish species.

Speckled dace apparently spawn in June and July over shallow rocky areas in the littoral zone (Miller, 1951). At spawning time small schools of dace can be seen, while at other times mature dace show no evidence of schooling behavior. Evans (1966) reported a catch of 233 dace in an overnight minnow trap set. This occurred in mid-June and may represent a spawning concentration. Dace probably also spawn in the tributaries of Lake Tahoe. Minnow traps set in Burton Creek from May through July 1965 began taking large numbers of ripe dace in early June, apparently during an upstream spawning migration.

ACKNOWLEDGMENTS

I am grateful to the many persons who have contributed to the project and this report. I especially wish to thank Ted C. Frantz of the Nevada Fish and Game Commission for providing the Cave Rock minnow trapping data, and Almo J. Cordone, who supervised the study

and assisted in preparation of this report. John D. Hopkirk read the manuscript and offered valuable suggestions. Cliffa E. Corson drew the figures.

REFERENCES

Calhoun, A. J. 1944. The food of the black-spotted trout (*Salmo clarkii henshawii*) in two Sierra Nevada lakes. Calif. Fish and Game, 30 (2) : 80–85.

Evans, Douglas H. 1966. Life history of the Lahontan redside, *Richardsonius egregius* (Girard), in Lake Tahoe. Univ. Calif. Berkeley, M.A. Thesis, 82 p.

Hopkirk, John D., and Robert J. Behnke. 1966. Additions to the known native fish fauna of Nevada. Copeia, 1966 (1) : 134–136.

Kimsey, J. B. 1950. Some Lahontan fishes in the Sacramento River drainage. Calif. Fish and Game, 36 (4) : 438.

La Rivers, Ira. 1962. Fishes and fisheries of Nevada. Nev. St. Fish and Game Comm., 782 p.

Linn, Jack D., and Ted C. Frantz. 1965. Introduction of the opossum shrimp (*Mysis relicta* Loven) into California and Nevada. Calif. Fish and Game, 51 (1) : 48–51.

McGauhey, P. H., Rolf Eliassen, Gerard Rohlich, Harvey F. Ludwig, and Erman A. Pearson. 1963. Comprehensive study on protection of water resources of Lake Tahoe Basin through controlled waste disposal. Engineering-Science, Inc., Oakland, Calif., 157 p.

Miller, Richard Gordon. 1951. The natural history of Lake Tahoe fishes. Stanford Univ., Ph.D. Dissertation, 160 p.

Murphy, Garth I. 1963. Trout survival in Taylor Creek, a tributary of Lake Tahoe, California. Calif. Fish and Game, 49 (1) : 16–19.

Rutter, Cloudsley. 1903. Notes on fishes from streams and lakes of northeastern California not tributary to the Sacramento basin. Bull. U.S. Fish Comm., 22 : 143–148.

Weidlein, W. Donald, Almo J. Cordone, and Ted C. Frantz. 1965. Trout catch and angler use at Lake Tahoe in 1962. Calif. Fish and Game, 51 (3) : 187–201.

Calif. Fish and Game, 53 (3) : 174-179, 1967.

TWO KING SALMON WITH SPAWNING FEATURES TAKEN IN OCEAN TROLL FISHERY[1]

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California Department of Fish and Game

Two king salmon, *Oncorhynchus tshawytscha* (Walbaum), part of the ocean troll catch landed in Eureka, California, in spring 1965, were unusual in that they exhibited features normally associated with sexual maturation and spawning. A discussion is presented.

In the spring of 1965, two king salmon, part of California's commercial ocean troll landings, were observed to have characteristics which usually are associated with sexual maturation, but which are quite unusual for ocean-caught king salmon.

Because it is well accepted that adult Pacific salmon (*Oncorhynchus* spp.) always die soon after spawning, the idea of finding a survivor of the experience is intriguing. Some steelhead trout, *Salmo gairdneri*, and Atlantic salmon, *Salmo salar*, spawn and recover, but not without recording the event on their scales. Hundreds of thousands of scales of salmon and trout have been examined by fisheries workers, yet there is no report of a spawning mark on a Pacific salmon scale.

DESCRIPTION

April 28, 1965, I received a phone call from the manager of Eureka Fisheries' salmon buying facility in Eureka, California, and was asked to look at an unusual king salmon. It had been caught in the ocean off the mouth of Mad River in northern California in about 30 fathoms by W. M. Sutherland of the commercial salmon troller *Legend*.

Sutherland reported the fish to be a female. He had examined the ovaries when he cleaned the fish. They were about the diameter of his thumb and lacked the firmness and form of maturing ovaries. He described the eggs as being small, hard, and light in color; being more yellow-orange than those of sexually maturing salmon. He said the eggs were not close together within the ovaries, and also reported that the stomach contained "small crabs" and the intestine contained fecal matter. All entrails were discarded at sea.

The fish had some of the body characteristics which usually develop in the freshwater portion of the spawning migration. The snout was hooked (particularly so for a female) and the jaws were lengthened noticeably (Figure 1). Enlarged teeth were present. This fish had less iridescence than all other king salmon in the catch, but would be considered a "fresh-run" fish had it been caught in a river and judged on color alone.

The fish was very lean, making the head and fins appear large. It measured 41 inches (104 cm) fork length and weighed $22\frac{1}{2}$ pounds dressed, head on. Ocean-caught kings of this length landed in Eureka

[1] Submitted for publication January 1967.

commonly weigh between 30 and 35 pounds (Fry and Hughes, 1951). The fins were in good condition. They showed no spawning wear.

The head, a small portion of kidney, and several scales were collected. Kidney matter from between the ribs was tested for tuberculosis, with negative results.

Scales were more difficult to remove from this fish than from other ocean-caught salmon. They had to be extracted from their skin pockets with forceps. Microscopic examination of the scales showed the posterior margin to be eroded and the anterior margin to be resorbed in places to a width of six circuli, with some variation among scales.

FIGURE 1—Ocean-caught female king salmon 41 inches (104 cm) FL. This fish shows characteristics usually associated with the stream portion of the spawning migration.
Photograph by C. L. Richardson, April 1965.

The scales were compared with others taken from spawning king salmon at Trinity and Nimbus salmon and steelhead hatcheries in California, and with scales from "normal" ocean-caught king salmon (Figure 2). Selection of a "typical" ocean scale was simple, as none showed resorption. Scales from spawners, however, exhibited resorption both to a greater and lesser extent than the subject scales.

May 3, 1965, five days after the first fish was found, I observed a second king salmon with similar characteristics. It had been caught near the ocean bottom in 38 fathoms between the mouth of Mad River and Trinidad Head, 9 miles north.

This fish was also very lean. It measured 43 inches (110 cm) FL and weighed 26½ pounds dressed, head on. It also had a hooked snout and lower jaw and some enlarged teeth. It had ocean coloration and a severe scar along the left side of the anal fin base. The scales showed erosion at the posterior margin. Kidney material was tested for tuberculosis, again with negative results.

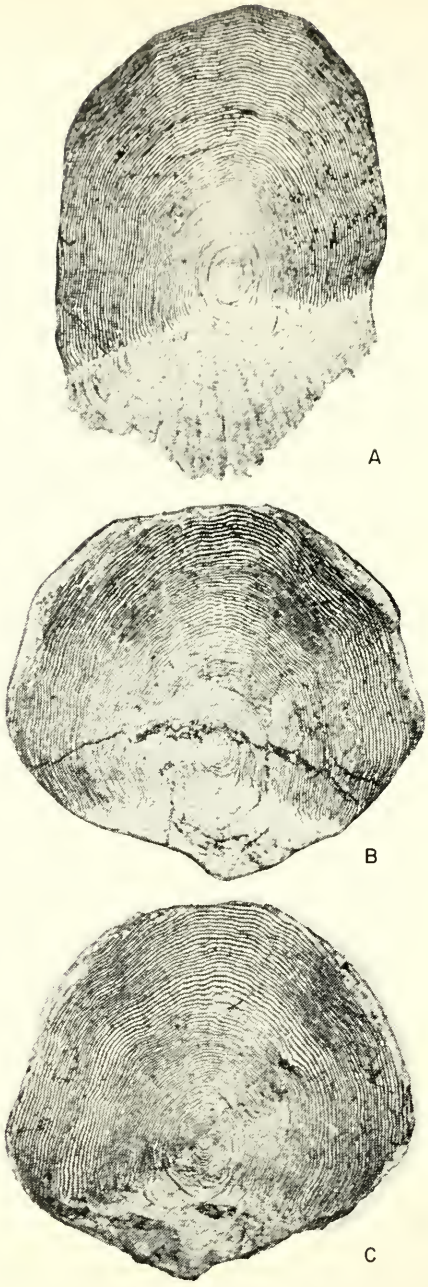

FIGURE 2—Comparison of scale condition of three king salmon. A, typical ocean-caught salmon. B, Subject ocean-caught salmon. C, Salmon spawned at Nimbus Hatchery, American River. *Photographs by Robert H. Gretzner, February 1966.*

Nic Puskar of the troller *Rose M* reported this fish provided little fight for its size. While the fish was being cleaned the gullet broke, showing that the fish had been feeding on what Puskar called "crab spawn". Sex of the fish was not determined.

DISCUSSION

The two fish were not typical ocean troll fish. Had they spawned and were they in the process of recovering when caught? The scales of the first fish were eroded to a degree that had the fish recovered from its poor condition, and continued to live in the ocean, the scales would exhibit a mark that would be similar or identical to the spawning marks seen on some steelhead trout and Atlantic salmon scales.

The fish were taken in late April and early May. This is not the most common time for California king salmon to be mature, but McLean (1945), Moffett and Smith (1950), and Menchen (1965) reported observations of spawned or spawning king salmon in California in late winter or in spring. Slater (1963) states that the experience of Coleman National Fish Hatchery personnel indicates that the spawning period of winter-run king salmon in the Sacramento River is from late April to late July.

Sutherland's description of his fish's eggs is not that of normally maturing eggs. The fish may have spawned and the fisherman may have seen residual eggs. If the fish had not yet spawned, the description indicates that the development of the gonads was not normal.

Rich (1921*a*) reported an instance of adult, sea-run king salmon in the Columbia River system continuing to feed on smelt while their sex products ripened. Could either of the Eureka fish have continued feeding after entering the river, spawned in the lower reaches, and drifted back into the ocean? If either fish actually did spawn, it would appear that it had gained back most of its ocean coloration and was recovering.

Rich (1921*b*), while determining relative maturity of ocean-caught salmon by egg diameter, learned that a small percentage of salmon found just within the mouth of the Columbia River were immature; however, he indicated that they were found only during unusual tidal conditions.

Robertson (1957) demonstrated that precociously mature male king salmon parr a few months old can spawn and survive in the hatchery. He thought that age was the deciding factor in determining death or survival following spawning. These two troll-caught fish were adults.

The suggestion that an adult Pacific salmon may have spawned, returned to the ocean, and was recovering is so contradictory to our understanding of these fish that it may be of interest to consider some additional possibilities.

Had these two fish entered the river physiologically unable to spawn and returned to the ocean?

Gibbs (1956) described a bisexual, adult steelhead trout taken in the South Fork of Eel River. The fish displayed the superficial appearance of a male. Its gonads appeared to have distinct male and female portions; however, some eggs were "embedded irregularly throughout the male tissue." Gibbs reported the eggs to be smaller than expected for sexually mature female steelhead of the same size.

There is similarity between the descriptions of the gonads of Sutherland's salmon and Gibbs' bisexual fish. Though unnoticed in the salmon, male tissue could have been there in sufficient quantity to interfere with final development of the eggs and/or prevent their release from the gonad. Sutherland's fish was judged a female because it contained eggs, yet its superficial appearance, like that of the bisexual fish, was that of a male.

Wood and Ordal (1958) indicate that tuberculosis may interfere with sexual maturation or normal migration patterns of king salmon. Tuberculosis test results were negative. However, this does not rule out other diseases.

Had the fish entered a river not yet ready to spawn, and then returned to the ocean?

Pacific salmon have been known to do this, but such action would not explain the physiological condition of the two king salmon under discussion.

McCully (1956) told of an adult king salmon tagged September 1953 in the Sacramento River near Fremont Weir, 126 statute miles upstream from the Golden Gate, being caught by a party boat fisherman May 1954 in the ocean near the Farallon Islands, about 30 miles off San Francisco. There is nothing in the report about the fish's appearance being unusual. Presumably this fish had made an early entry into the river and had returned to the sea without spawning.

Had their spawning migration been interrupted and had they temporarily left the river?

King salmon in the San Joaquin River, California, in 1964 were tagged with sonic tags which permitted monitoring their movements. Most were observed to move downstream rapidly and remain for from a few hours to several days before returning as far as the tagging site (California Department of Fish and Game, 1965). McCully (1956) reported that 1.2% of the king salmon tagged in one period at Fremont Weir (15% of the recoveries) were recovered in the gill net fishery more than 62 miles downstream from the tagging site. (Until 1957, commercial gill net fishing was legal in the Sacramento River.) The tagged fish in the gill nets had not spawned and appeared no different than other salmon taken.

Tait, Hout, and Thorsteinson (1962) reported that 21 red salmon, *O. nerka*, out of 1,934 tagged 11 miles up the Kenai River, Alaska, were recovered the same season in the Cook Inlet commercial fishery.

Such evidence suggests either that the experience of being captured and tagged causes some fish to reverse course and proceed downstream or that a moderate number of immature salmon enter streams and return to the ocean. The fish landed at Eureka had not been tagged, but an interrupting experience could conceivably have caused them to reenter the ocean.

Could their migration into the river have been delayed to the extent that they were maturing or had spawned in the ocean?

This could happen if the homing instinct or navigational ability of these fish had gone awry or if there had been some physical block which prevented their entering fresh water.

A small adult pink salmon, *O. gorbuscha*, taken by a boy diver in the ocean at La Jolla, California, in September 1945, was reported by

Hubbs (1946) as a southern range extension. The fish had slightly hooked jaws, enlarged canine teeth, and body cavity filled with mature eggs. Leo Shapovalov, California Department of Fish and Game, examined a sample of the scales and found them to show spawning absorption or erosion along their outer margins. Pink salmon often spawn in intertidal water. Therefore, it is fairly easy to accept that a pink salmon could mature in the ocean. Maturation of gonads of king salmon regularly begins in the ocean. Perhaps a king salmon would continue to mature if it remained in the ocean.

SUMMARY

Two king salmon landed at Eureka were recognized by salmon dealers as being unusual. Both were caught in the ocean and possessed features associated with sexual maturation at a time when relatively few California king salmon are maturing. The coloration of one and the scales of both were unusual. Both were underweight, of similar length, and were caught from the same area on different days. Either could have moved into a river to spawn, to feed, or for any other reason, and returned to the sea. Either may have completed sexual development in the ocean, as did a pink salmon taken off southern California.

REFERENCES

California Department of Fish and Game. 1965. 1964 Delta salmon migration study (sonic tag phase). Staff, Salmon/Steelhead Program, Feb. 1965, 18 p. (Typewritten)

Fry, Donald H. Jr., and Eldon P. Hughes. 1951. The California salmon troll fishery. Pac. Mar. Fish. Comm., Bull., (2) : 7–42.

Gibbs, Earl D. 1956. A bisexual steelhead. Calif. Fish and Game, 42 (3) : 229–231.

Hubbs, Carl L. 1956. Wandering of pink salmon and other salmonid fishes into southern California. Calif. Fish and Game, 32 (2) : 81–86.

McCully, Howard. 1956. An undescribed type of migration in king salmon, *Oncorhynchus tshawytscha* (Walbaum). Calif. Fish and Game, 42 (3) : 189–198.

McLean, Donald D. 1945. Late spring spawning of chinook salmon (*Oncorhynchus tshawytscha*). Calif. Fish and Game, 31 (4) : 211.

Menchen, Robert S. 1965. An observation of king salmon spawning successfully in Deer Creek in March 1964. Calif. Fish and Game, 51 (1) : 53–55.

Moffett, James W., and Stanford H. Smith. 1950. Biological investigations of the fishery resources of Trinity River, California. U. S. Fish and Wildl. Serv., Spec. Sci. Rept.—Fish., 12 : 71 p.

Rich, Willis H. 1921*a*. An instance of adult, sea-run chinook salmon found feeding in fresh water. Calif. Fish and Game, 7 (1) : 7–8.

—1921*b*. The relative maturity of the chinook salmon taken in the ocean along the Pacific coast. Calif. Fish and Game, 7 (1) : 12–22.

Robertson, O. H. 1957. Survival of precociously mature king salmon male parr (*Oncorhynchus tshawytscha* Juv.) after spawning. Calif. Fish and Game, 43 (2) : 119–130.

Slater, Daniel W. 1963. Winter-run chinook salmon in the Sacramento River, California with notes on water temperature requirements at spawning. U. S. Fish and Wildl. Serv., Spec. Sci. Rept.—Fish., 461 : 9 p.

Tait, Howard D., J. L. Hout, and F. V. Thorsteinson. 1962. An evaluation of fyke trapping as a means of indexing salmon escapements in turbid streams. U. S. Fish and Wildl. Serv., Spec. Sci. Rept.—Fish., 428 : 18 p.

Wood, James W., and Erling J. Ordal. 1958. Tuberculosis in Pacific salmon and steelhead trout. Fish Comm. Oregon, Contribution, 25 : 38 p.

Calif. Fish and Game, 53 (3) : 180-184, 1967.

PRELIMINARY EXPERIMENTS ON THE ACCLIMATIZATION OF JUVENILE KING SALMON, *ONCORHYNCHUS TSHAWYTSCHA*, TO SALINE WATER MIXED WITH SEWAGE POND EFFLUENT[1]

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The survival of king salmon in six experiments was tested in the following solutions: sea water from Humboldt Bay mixed with hatchery water, effluent from Arcata oxidation pond, and sea water from Humboldt Bay mixed with effluent. The experiments were carried out at hatchery facilities of Humboldt State College from February 2 through July 8, 1965. Six-week-old salmon showed tolerance to high salinities, but at 9 weeks of age tolerance of the fish decreased. After 9 weeks the salmon showed increasing tolerance to higher salinities with increasing age. Maximum survival occurred in mixtures of effluent and sea water. These mixtures also showed a therapeutic effect when the salmon were suffering mortalities from an unidentified internal parasite. Results indicated the desirability of field experiments to test the hypothesis that sewage effluent could be used to increase natural foods in saline ponds to rear salmon.

The city of Arcata, California, on the northern arm of Humboldt Bay, gives primary and secondary treatment to its domestic sewage. The effluent from this treatment is discharged into a 50-acre oxidation pond (stabilization lagoon), located on mud flats of the intertidal zone of Humboldt Bay (Hazel, 1963).

Domestic sewage, either raw or treated, is a recognized fertilizer. It was hypothesized that the effluent from the Arcata oxidation pond could be used to increase natural foods for fish in rearing ponds constructed adjacent to the oxidation pond. (Also, the rearing pond would provide additional biological treatment to the oxidation pond effluent, thereby producing a higher quality discharge into Humboldt Bay.)

As a preliminary step, experiments on the tolerance of young king salmon to various salinities and the effluent from the Arcata oxidation pond were carried out in the fish cultural facilities at Humboldt State College.

METHODS

Eyed eggs, obtained through the cooperation of the California Department of Fish and Game from the Iron Gate fish cultural facilities on the Klamath River, were received on December 7, 1964, and began hatching on December 27. A series of six experiments using these salmon began on February 2 and ended on July 8, 1965 (Table 1).

[1] Submitted for publication August 1966.
[2] The junior author is now with Marine Resources Operations, California Department of Fish and Game.

TABLE 1

Experiments on Survival of Juvenile King Salmon in Combinations of Hatchery, Oxidation Pond, and Sea Water, Humboldt State College Hatchery, February–July, 1965

	Experiment number					
	1	2	3	4	5	6
Date of experiment						
Beginning	February 2	February 24	March 17	April 14	May 12	June 30
End	February 16	March 10	March 30	April 27	May 25	July 8
Duration of experiment in days	14	14	13	13	13	8
Number of individual trials (tanks)	8	7	8	8	8	6
Number of salmon per tank	50	50	50	50	50	25
Range in water temperature (F)	48–52	50–54	54–58	55–60	57–64	60–62
Mortality percentages						
Control—hatchery water alone:	0	20	2	76	72	0
Test A—hatchery water mixed with sea water						
5.0 °/₀₀	0					
8.5 °/₀₀						96*
10.0 °/₀₀	0					
15.0 °/₀₀	0					
17.0 °/₀₀			18	14	6	
19.0 °/₀₀		70	16	6	2	
20.0 °/₀₀	1					
21.0 °/₀₀		80	48	30	8	
23.0 °/₀₀		100	60	100†	24	
25.0 °/₀₀	80	100	80	76†	54	16‡
34.0 °/₀₀						60‡
Test B—oxidation pond water alone	0	28	12	56	34	100‡
Test C—oxidation pond water mixed with sea water						
10.0 °/₀₀	2					
15.0 °/₀₀		24	0	14	2	
17.0 °/₀₀						0

* 61% of this mortality occurred in 1 day when the air supply was cut off because of a clogged air filter. No other explanation for this mortality is known.
† All mortality occurred in the first 4 days of period.
‡ All mortality occurred in the first 3 days.
-- Experiment not conducted.

In each of the experiments, the short-term mortality of juvenile salmon was tested in the following solutions: sea water from Humboldt Bay mixed with hatchery water to produce selected salinities (test A), oxidation pond water (effluent) alone (test B), and sea water from Humboldt Bay mixed with oxidation pond water to produce several selected salinities (test C). A control group in hatchery water was maintained during each experiment.

The broad range of salinity levels in test A of the first experiment was selected to locate the critical area for salinity tolerance of juvenile king salmon. On the basis of the results of this experiment and preliminary information derived from salinity tolerance experiments at the Alsea Laboratory of the Oregon State Game Commission (H. J. Rayner and F. L. Garrison, pers. commun., Dec. 7, 1964), salinities of 17, 19, 21, 23, and 25‰ (parts per thousand) were chosen to provide 2‰ increments around what appeared to be a critical point for acclimatization (20‰). In experiment 2, the tank for test A with 17‰ was not assembled because of an oversight. Initially, the experiments had been planned to run during the period of instruction at the college and to finish with experiment 5 the end of May. Examination of results of the first five experiments urged another experiment, so experiment 6 was added. Only six aquaria were available for this experiment. Salinities for test A of 8.5, 25, and 34‰ were selected. The higher salinities were chosen because the data indicated an increasing tolerance to higher salinities with increasing age.

For test C, an initial salinity of 10‰ was chosen arbitrarily. This was increased to 15‰ for the following four experiments. In the final experiment, it was increased to 17‰ because of increasing tolerance, as indicated above for salinities in Test A, experiment 6.

Each of eight 25-gallon aquaria was fitted with a commercially available spun glass and charcoal filter designed for home aquaria. Compressed air was forced through each filter to circulate the water through the filter and insure oxygen saturation in the aquarium.

Temperature fluctuation through the course of an experiment was minimized by placing the aquaria in troughs, where ambient hatchery water provided insulation. Temperatures during the series of experiments gradually increased with the normal seasonal warming of water in the hatchery. Day-to-day variation usually did not exceed 1 or 2 F, although in a few 1- or 2-day periods increases in temperature of 2 to 3 F occurred.

In experiments 1 through 5, each solution was tested with 50 salmon. Control groups also contained 50 salmon. In experiment 6, the number of fish was reduced to 25 to prevent overcrowding, since the fish had grown considerably by the end of June.

Experiments 1 through 5 were run for 13- and 14-day periods; experiment 6 was run for 8 days.

RESULTS

The results of the experiments are reported in terms of mortality percentages (Table 1). Several peculiar results appeared. The first was an unexpectedly low mortality of very young salmon fry in all but one salinity tested in experiment 1. Only at 25‰ salinity did any mortality occur. The second appeared in experiment 2, when older fish showed

70% mortality at 19‰. Unfortunately, no fish were tested at 17‰ in experiment 2. As the fish grew older (experiments 3–6), an increasing tolerance to higher salinities occurred, eventually exceeding that shown by the very young salmon fry in experiment 1. We are not able to explain the apparently anomalous results of high initial tolerance to relatively high salinities in experiment 1 followed by the much lower tolerance in experiment 2.

An epizootic of internal protozoans caused mortalities in all hatchery fish, including test fish, from late March until mid-June. We were unable to identify these parasites.

In experiments 4 and 5, salt water had a pronounced therapeutic effect on the salmon at a time when the control fish were suffering considerable mortality. Oxidation pond water also had a therapeutic effect.

A consistently low mortality in our experiments occurred in a mixture of oxidation pond water and sea water (test C).

DISCUSSION

Surprisingly, the undiluted effluent from the oxidation pond was not toxic to the salmon until early summer (experiment 6). The oxidation pond receives raw sewage as overflow when the sewage treatment plant is not able to treat the entire incoming flow during heavy rains. Although storm drains are separate from the sewage system, there is considerable leakage of storm water into the sewage lines. The pond received maximum flushing from storm waters during heavy rains in December 1964, but it is doubtful that the dilution persisted until June. Thus, it appears that during much of the year the Arcata pond effluent alone is of sufficiently high quality to rear juvenile king salmon.

Average monthly salinities of 32–34‰ characterized north Humboldt Bay in 1961–62 at a point about 2 miles southwest of the oxidation pond (Skeesick, 1963; Jacoby Creek Station, Table 5). Periods of rainy weather reduced the salinity to a low of about 28‰ during February. Since Humboldt Bay has a high flushing rate, periods of low salinity are of relatively short duration. Even the 28‰ encountered in February 1962 is considerably higher than the 15–17‰ which our experiments indicated would be an initially desirable salinity for young king salmon. Increasing the salinity of the pond with the growth of the salmon might be desirable.

Presumably, temperatures in the rearing pond would have to be kept low. Summer water temperatures in north Humboldt Bay (thermograph records of the California Department of Fish and Game) are below 70 F, and generally in the low 60's. At all other times the temperatures are below 60 F. How temperature might affect the ability of salmon to acclimatize could not be shown by the present experiments.

CONCLUSIONS

Most municipal and industrial effluents in California are discharged into coastal saline waters (Pearson, Pomeroy, and McKee, 1960). Thus, a large fish production potential might be exploited with the successful development of saline fish rearing facilities fertilized with sewage effluents.

The results of these preliminary laboratory experiments seem to justify testing of the hypothesis in the field by constructing small experimental ponds adjacent to the Arcata stabilization lagoon. Land to construct a series of 1-acre ponds is available. One such pond would receive sea water from Humboldt Bay only. Other ponds could receive different volumes of effluent from the stabilization lagoon. Equal numbers of young salmon could be planted into the ponds and the results of fertilization measured by the survival, growth, and physical condition of the fish after chosen time intervals.

REFERENCES

Hazel, Charles R. 1963. Chlorophyll and non-astacin pigment concentration, and photosynthetic oxygen production in a sewage oxidation pond. Humboldt State College, M.S. Thesis, June 1965.

Pearson, Erman A., Richard D. Pomeroy, and Jack E. McKee. 1960. Summary of marine waste disposal research program in California. State Water Pollution Control Board, Publ. No. 22, 77 p.

Skeesick, Delbert C. 1963. A study of some physical-chemical characteristics of Humboldt Bay. Humboldt State College, M.S. Thesis, June 1963.

Calif. Fish and Game, 53 (3) : 185-191. 1967.

FISH REMAINS RECOVERED FROM A CORONA DEL MAR, CALIFORNIA, INDIAN MIDDEN (ORA-190)[1,2]

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The washed screenings from approximately 0.6 ft.^{3} of Indian midden yielded 133 fish vertebrae, teeth, otoliths, and other remains from which five species of sharks and six kinds of bony fishes were identified. Most of these fishes undoubtedly were caught by the Indians, but the arrow goby and northern anchovy otoliths probably arrived at the midden in the stomachs of predatory species.

During excavation of an Orange County, California, Indian midden by members of the Pacific Coast Archaeological Society, a 6-inch square column of midden soil was saved from their pit H-28 so that I could process the sample for fish remains. The site the Indians had occupied, designated Buck Gulley #1 Site, Ora-190, is "on the 300-foot terrace above the town of Corona del Mar, 10,000 feet southeast of Newport Bay" (Paul G. Chace, pers. commun.). The midden at pit H-28 was 30 inches deep, so the special sample comprised five units, representing sequential 6-inch horizontal levels.

I processed the material from each unit separately, using a technique that has proven highly successful for recovering fish remains from fossil deposits (Fitch, 1966), and which recently yielded identifiable fish remains from 45 species that had been utilized by the Chumash Indians at Ventura, California (Fitch, MS).

Using a metal tub, I submerged each 6-inch unit from the special sample in sufficient water to produce a soupy mixture that could be manipulated easily in fine-mesh screens. Next, I fitted three sieves together (2, 1, and 0.5 mm, U. S. Standard Sieve Series), with the largest mesh on top, and then washed the soupy mixture through these screens a couple of quarts at a time. The clean residue retained by each screen was dumped onto newspapers and allowed to dry in the sun. Since the 9-mesh screen (2 mm) had retained an assortment of coarse non-fish material (rock and shell fragments primarily), this was removed by rescreening with ¼-inch mesh. The coarse residue retained by the ¼-inch mesh was scrutinized by eye, but the remaining material was spread evenly, one tablespoonful at a time, in a square, plastic icebox-dish lid with slightly raised edges, and examined through a binocular microscope at six magnifications.

Although the coarsest screenings yielded but a single, unidentified teleost (fish) vertebra, the residue from the finer screens contained

[1] Submitted for publication January 1967.

[2] Various sites in California that have been occupied by Indians are designated by a series of three letters followed by one or more numbers. The letters indicate the county in which the midden is located, and the numbers specify a particular midden within that county. In southern California, personnel of the Archeological Survey, University of California Los Angeles, assign numbers as middens are reported and maintain a master file for the area. The Division of Beaches and Parks, Sacramento, performs the same function for northern California, and maintains a master file for the entire state. Thus Ora-190 is the 190th site recognized in Orange County.

132 items that could be assigned to 11 species of fishes: 5 elasmobranchs and 6 teleosts (Table 1). In addition, numerous rodent teeth, vertebrae, and other bony fragments were present in the residue retained by the 9-, 18-, and 32-mesh screens; and tiny, charred plant

TABLE 1

Fish Remains from a Corona del Mar Indian Midden (Ora-190)

Scientific name	Common name	Depth (inches) 0–6	6–12	12–18	18–24	21–30
	Sharks, rays, skates					
Heterodontus francisci	Horn shark	1jt			1jt	
Platyrhinoidis triseriata	Thornback					1dd
Rhinobatis productus	Shovelnose guitarfish			1jt		
Squatina californica	Pacific angel shark			3dd	1dd	2dd
Triakis semifasciata	Leopard shark				1jt	
Unidentified elasmobranchs		2v	2v	1v		1v
		1dd			1dd	
	Bony fishes					
Amphistichus argenteus	Barred surfperch			1pt		
Calamus brachysomus	Porgy	2jt				
Clevelandia ios	Arrow goby				1o	
Engraulis mordax	Northern anchovy		1o			
Paralabrax sp.	Bass	1jt				
Pimelometopon pulchrum	Sheephead	3jt		4jt	1jt	2jt
				1pt		1pt
Unidentified bony fishes		5v	26v	26v	21v	3v
		2jt	2jt	1jt	2jt	4jt
					1pt	

jt = jaw tooth; pt = pharyngeal tooth; dd = dermal denticle; o = otolith; v = verterbra.

seeds were very abundant, particularly in the finest material. While these plant and rodent remains may not represent food items, their presence in the midden indicates that they were living in the area at the time the site was occupied, and they offer an excellent opportunity for some enterprising archaeologist to improve our knowledge of the Indian's environment. Finally, a disk-type shell bead 4.5 mm in diameter was retained by the 9-mesh screen from the 18- to 24-inch horizon.

SYSTEMATIC ACCOUNT

Heterodontidae—horn sharks

Heterodontus francisci (Girard)—horn shark

Horn sharks are abundant in rocky subtidal areas between about Morro Bay, California, and Magdalena Bay, Baja California. They reach lengths of about 3½ feet, and weights of about 25 pounds. They are active mostly at night, when they are foraging for food. Although they will take a baited hook, they are easily caught in fish or lobster traps which are set overnight, and can be taken abundantly with gill nets. On rare occasions, horn sharks are found hiding under large boulders in shallow intertidal areas. The Indians who occupied Ora-190 probably captured horn sharks incidental to other fishing activities (including intertidal scrounging) along the rocky outer coast. Horn shark remains have been reported from a Chumash site at Ventura (Fitch, MS).

Material: 2 teeth, from the 18- and 32-mesh screens.

Triakidae—leopard sharks

Triakis semifasciata Girard—leopard shark

The leopard shark ranges from about Oregon to Manzatlan, and is also found in the northern Gulf of California. It usually frequents shallow areas where the bottom is sandy, including bays and lagoons. A 5-footer weighing 40 to 45 pounds would be a large individual, although they may reach 7 feet. Leopard sharks are easy to catch on hook and line, especially at night; they also can be speared without too much difficulty. Although present-day fishermen catch leopard sharks primarily with gill nets, the inhabitants of the Ora-190 site probably relied almost entirely upon hook and line, and the harpoon or spear, for obtaining fish. Leopard shark remains have been reported from a Ventura site (Fitch, MS) and from middens at Arroyo Sequit, the Century Ranch, and Drakes Bay (Follett, 1963*a*,*b*, 1964).

Material: 1 tooth from the 9-mesh screen.

Squatinidae—angel sharks

Squatina californica Ayres—Pacific angel shark

Pacific angel sharks range from southern Alaska into the Gulf of California, but they are not abundant north of Point Conception. They usually are seen in sandy areas along the outer coast at depths shallower than 150 feet; they rarely enter shallow bays or lagoons. A 44-inch female, the largest of several hundred individuals examined during a 3-year period, weighed 31 pounds. The Indians probably caught angel sharks on hook and line in intermediate depths outside the surf zone. The habits of these sharks preclude the use of spears, except by divers. Angel shark remains have been reported from coastal Indian middens at Ventura by Fitch (MS) and at Point Mugu, Arroyo Sequit, and the Century Ranch by Follett (1932, 1963*a*,*b*).

Material: 6 dermal denticles from the 32-mesh screen.

Rhinobatidae—guitarfishes

Rhinobatos productus (Ayres)—shovelnose guitarfish

The shovelnose guitarfish is one of the more common elasmobranchs throughout much of its range between Monterey Bay and the Gulf of California. It usually inhabits shallow sandy areas along the outer coast, but often enters shallow bays and lagoons. Sometimes large individuals will feed high up on the shore in the wash of breaking waves, often almost stranding themselves as a wave recedes. These individuals can be harpooned or caught by hand if one is quick enough, but most of the shovelnose guitarfish the Ora-190 Indians caught probably were taken with hook and line. A record-sized female was 61½ inches long and weighed 40½ pounds. Shovelnose guitarfish remains have been reported from a Ventura midden (Fitch, MS) and from Chumash sites at Arroyo Sequit and the Century Ranch (Follett, 1963*a*,*b*).

Material: 1 tooth from the 32-mesh screen.

Platyrhinoidis triseriata (Jordan and Gilbert)—thornback

The thornback ranges from about Elkhorn Slough, California, to Sebastian Viscaino Bay, Baja California, but is rare north of Morro Bay. On the outer coast it seems to prefer sandy areas outside the

breaking surf, but at times thornbacks will aggregate on tidal flats in bays and lagoons. In the ocean, they are readily caught with hook and line, but when concentrations appear on the tidal flats of bays and lagoons they can be caught by hand, speared, etc. A large individual might be 30 inches long and weigh 6 or 7 pounds. Fitch (MS) reported thornback remains from a Chumash site at Ventura.

Material: 1 dermal denticle or "spine" from the 32-mesh screen.

Unidentified elasmobranchs

Among the unidentified shark, skate, and ray remains from the Ora-190 special sample are 6 small vertebrae(mostly from the 9- and 18-mesh screens), and 2 "dermal denticles" similar to those found around the "lips" of *Squatina*, *Triakis*, *Mustelus*, and a few other sharks. These tiny denticles were both in the 32-mesh screen.

Engraulidae—anchovies

Engraulis mordax Girard—northern anchovy

The northern anchovy is a schooling fish that ranges from British Columbia to Magdalena Bay and offshore for several hundred miles. They are reported to attain a length of 9 inches, but specimens larger than 7 inches seldom are seen in nearshore areas. An 8-inch fish will weigh about 2 ounces. I have no doubt that some coastal Indians fished for and caught anchovies, but the single otolith recovered at Ora-190 (Figure 1) showed signs of having been eroded by digestive action,

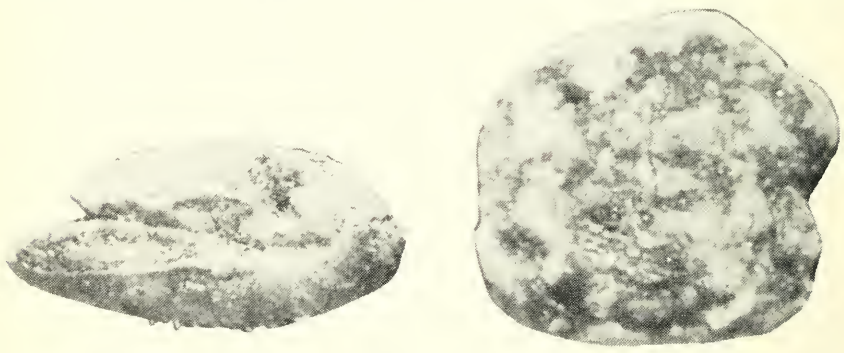

FIGURE 1—Fish otoliths recovered from a Corona del Mar, California, Indian midden: left, right sagitta of northern anchovy 3.3 mm long; right, left sagitta of arrow goby 1.2 mm long. *Photographs by Jack W. Schott.*

which would indicate that it had been in the stomach of some predatory fish or bird the Indians had utilized. Northern anchovy otoliths were fairly common in a Chumash midden at Ventura (Fitch, MS).

Material: 1 otolith from the 32-mesh screen.

Serranidae—basses

Paralabrax sp.—sand or kelp bass

Three species of *Paralabrax* are abundant in shallow waters along the southern California coast. The kelp bass, *P. clathratus*, prefers rocky habitat, especially where kelp beds are prolific. Of the other two,

P. nebulifer is the most likely to be found on sandy-bottom areas of the outer coast, while *P. maculatofasciatus* is most common on the same type of substrate within bays and lagoons. All three species are easily hooked or trapped (lobster or fish traps), and one or both techniques probably were used by the Indians who inhabited Ora-190. *P. clathratus* attains a weight of at least 15 pounds, but the other two species are smaller; *P. nebulifer* possibly attains 10 pounds, and *P. maculatofasciatus* 6 or 7. Follett (1963*a*,*b*) has reported *P. nebulifer* remains from Chumash sites at Arroyo Sequit and the Century Ranch.

Material: 1 canine-like jaw tooth from the 18-mesh screen.

Sparidae—porgies

Calamus brachysomus (Lockington)—Pacific porgy

The present-day range of the Pacific porgy extends from Oceanside, California, to south of Lima, Peru, but the species is rarely seen north of Sebastian Viscaino Bay, Baja California. Adults rarely are found in depths greater than 150 feet, and are abundant in shallow, sandy areas of the outer coast as well as inside coastal bays and lagoons; juveniles occur in great numbers over shallow tidal flats of coastal bays and lagoons. A large individual might be 20 inches long and weigh 6 or 7 pounds. The Pacific porgy is easily taken on hook and line, which is probably how the Indians caught theirs, but they might also have speared the porgy in the shallows of Newport Bay.

Material: 2 teeth from the 18-mesh screen.

Embiotocidae—surfperches

Amphistichus argenteus Agassiz—barred surfperch

Barred surfperch range from Bodega Bay, California, to Playa Maria Bay, Baja California. They have been captured in depths exceeding 50 feet, but they are primarily inhabitants of the breaking surf along sandy beaches of the outer coast. Barred surfperch are superior bait thieves, and because of this they are difficult to hook even though they "bite" readily. They would be an easy target for an experienced spear thrower standing in shallow water scanning the areas between shoreward-rolling waves, and I suspect that this was the principal technique employed by the Ora-190 Indians. A record-sized fish was 17 inches long and weighed 4¼ pounds. Barred surfperch remains were reported by Fitch (MS) from a Ventura Chumash site.

Material: 1 pharyngeal tooth from the 18-mesh screen.

Labridae—wrasses

Pimelometopon pulchrum (Ayres)—California sheephead

California sheephead range from Monterey Bay to and into the Gulf of California. Throughout much of this area they abound in rocky areas, particularly where dense kelp beds grow. They have been reported to attain lengths of 3 feet and a weight of 36¼ pounds, but individuals exceeding 30 inches and 25 pounds are extremely rare. Sheephead will "bite" on an assortment of baits, but they are difficult to hook because of heavy, protruding teeth and an ability to nibble at the edges of the bait. They are easy to capture in fish and lobster traps, and underwater spearfishermen take a heavy toll each year.

Sheephead apparently were a favorite prey of the coastal Indian, and their distinctive massive jaws and teeth are usually retained by the large-mesh screens used by archaeologists, so *P. pulchrum* remains have been reported from many middens including sites at Arroyo Grande, Ventura, Point Mugu, Arroyo Sequit, the Century Ranch, La Jolla, San Nicolas Island, and Santa Catalina Island (Fitch, in press; Follett, 1932, 1963*a,b*; Meighan, 1959; Meighan and Eberhart, 1953; Mitchell, 1959; Shumway, Hubbs, and Moriarty, 1961; Wallace, 1962).

Material: 13 jaw teeth (mostly from the 32-mesh screen) and 2 segments of fused pharyngeals from the 9- and 18-mesh screens.

Gobiidae—gobies

Clevelandia ios (Jordan and Gilbert)—arrow goby

The arrow goby ranges from Vancouver Island, British Columbia, to at least San Quintin Bay, Baja California. Typically it inhabits mud flats of back bays and lagoons, and has been reported from rivers and streams that enter these bays. Because a large arrow goby, perhaps 2 inches long, would not weigh much more than a good-sized kitchen match, I do not believe the Indians either fished for or caught them. Reeder (1951) reported finding 120 *C. ios* otoliths in the stomach of a greater yellow-legs (*Totanus melanoleucus*), and 27 more in the stomach of a short-billed dowitcher (*Limnodromus scolopaceus*), so the occurrence of goby otoliths in shorebird stomachs is fairly well documented. I feel quite certain that the single *C. ios* otolith I recovered (Figure 1) from the Ora-190 midden arrived there in the stomach of some shorebird (willet, curlew, yellow-legs, dowitcher, etc.) the Indians had killed or found.

Material: 1 otolith from the 32-mesh screen.

Unidentified teleost remains

Vertebrae were the most abundant of the unidentified bony fish remains from this site, being found in all screens and at all depths. Some of these 81 vertebrae probably came from the same species as listed above, but I believe that they represent a minimum of four or five additional species. Other unidentified teleost remains include 11 jaw teeth and 1 pharyngeal tooth, primarily from the 18- and 32-mesh screens.

DISCUSSION

The use of fine-mesh sieves and a microscope to examine washed screenings from a relatively minute portion (about 0.6 ft.^{3}) of the 1,800 ft.^{3} of midden excavated at Ora-190 yielded considerable information regarding the fin fishes utilized by the Indians, and permits speculation about their fisheries.

The relative dearth of fish remains, compared to Ven-3, Arroyo Sequit, the Century Ranch, and similar middens, indicates that the inhabitants of Ora-190 were not marine oriented, even though they seem to have been familiar with seagoing craft. To obtain at least 3 and possibly 4 of the 11 species identified from this midden (angel sharks, bass, porgy, and sheephead), the Indians would have had to use some type of craft that would float and could be propelled, although a raft would have been adequate, because none of the fisheries would have necessitated trips into rough water or more than 100 yards or so

offshore. It does not appear that this group of Indians utilized such efficient types of gear as gill nets, beach seines, etc., or a great many more fish remains would have been found in the midden, even though not all food items harvested were taken home.

Although this group of Indians apparently utilized hook and line for several species and may have used traps, I believe that many of the fishes they took were speared as the opportunity arose while various individuals were scrounging the shoreline for mollusks, crustaceans, and whatever else they could find that was edible.

The relatively small quantity of midden soil saved for fish analysis precludes an exhaustive evaluation of the fishes utilized by the occupants. Unfortunately, 80 to 100 man-hours are needed to process an adequate sample (at least 10 $ft.^3$), and since most qualified individuals who could do this work are employed full time in fields of endeavor other than archaeology, it is extremely difficult for the archaeologist to find a specialist who is willing to undertake the task or who can spare that much of his "free" time.

ACKNOWLEDGMENTS

My research on fish otoliths has been supported in part by a grant from the National Science Foundation (GB-1244). In addition, I wish to thank Paul G. Chace for having saved for me the sample from Ora-190 upon which this report is based. Mrs. Roberta Greenwood, Pacific Palisades, reviewed the manuscript and offered several helpful suggestions; Jack W. Schott took the excellent photographs; and Mrs Loretta Morris typed the manuscript in its several revisions.

REFERENCES

Fitch, John E. 1966. Additional fish remains, mostly otoliths, from a Pleistocene deposit at Playa del Rey, California. Los Angeles Co. Mus., Contrib. in Sci., (119) : 1–16.

Follett, W. I. 1932. Incomplete list of fishes from Point Magu [sic] shellmound. Los Angeles Co. Mus. Nat. Hist., unpubl. ms.

——— 1963*a*. Fish remains from Arroyo Sequit Shellmound (LAn-52), Los Angeles County, California. Calif. Dept. Parks and Rec., Div. Beaches and Parks, Archaeological Rept., (9) : 113–121.

——— 1963*b*. Fish remains from the Century Ranch Site (LAn-227), Los Angeles County, California. Ann. Rept. 1962–1963, Archaeological Surv., Univ. Calif. Los Angeles p. 299–313.

——— 1964. Fish remains from a Sixteenth Century site on Drakes Bay, California. Ann. Rept. 1963–64, Archaeological Surv., Univ. Calif. Los Angeles, p. 31–41.

Meighan, Clement W. 1959. The Little Harbor Site, Catalina Island: an example of ecological interpretation in archaeology. Amer. Antiquity, 24 (4) : 383–405.

Meighan, Clement W., and Hal Eberhart. 1953. Archaeological resources of San Nicolas Island, California. Amer. Antiquity, 19 (2) :109–125.

Mitchell, Edward D., Jr. 1959. Appendix IV. Faunal and human skeletal remains. Archaeological Surv. Assoc. So. Calif., Los Angeles, Pap. 4, p. 151–153.

Reeder, William G. 1951. Stomach analysis of a group of shorebirds. The Condor, 53 (1) : 43–45.

Shumway, George, Carl L. Hubbs, and James R. Moriarty. 1961. Scripps Estate Site, San Diego, California: a La Jolla site dated 5460 to 7370 years before the present. Ann. N.Y. Acad. Sci., 93 (3) : 37–132.

Wallace, William J. 1962. Archaeological investigations in the Arroyo Grande Creek watershed, San Luis Obispo County, California. Ann. Rept. 1961–62, Archaeological Surv., Univ. Calif. Los Angeles, p. 23–66.

PARTYBOAT LOGS SHOW HOW SKINDIVERS FARED DURING 1963 AND 1964[1]

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During 1963 and 1964, catch records of 10,753 California skindivers show abalone, kelp bass, and spiny lobster to be the most important species. Diving success, in various areas, ranged from 0.6 to 5.5 fish, shellfish, and crustaceans per day.

Shortly after World War II, self-contained underwater breathing apparatus (SCUBA), better skindiving equipment, and expert instruction became readily available. Consequently, many thousands of Californians have been lured to explore the ocean off the nearby coast and adjacent islands. Due to this increased popularity of skindiving, a fleet of charter boats catering to the needs of the skindiver has appeared. These vessels have air compressors for filling SCUBA tanks, ladders for easy access to and from the water, and tank storage racks. California law (State of California, 1963) requires the operators of these diving charters to keep daily records of the fish taken from their boats. Young (1961) and Wood (1964) have summarized partyboat skindiving activity for the period 1958 through 1962. All diving catch records received during 1963 and 1964 are summarized in this paper, except for a few unreadable, incomplete, or improbable logs.

TABLE 1

Marine Species Catch and Effort by Diving Area, Central California, 1963 and 1964

	Catch by area							
	Bodega Bay		Morro Bay		Monterey Peninsula		Total	
Common name	1963	1964	1963	1964	1963	1964	1963	1964
Abalone*	25	--	--	9	24	--	49	9
Rockfish*	--	--	--	3	21	20	21	23
Sea urchins	--	--	--	--	30	--	30	--
Lingcod	--	--	--	--	5	13	5	13
Scallop, rock	--	--	--	--	--	15	--	15
Cabezon	--	--	--	1	12	--	12	1
	25	--	--	13	92	48	117	61
Number of trips	1	--	--	1	3	5	4	6
Number of divers	5	--	--	9	54	81	59	90
Number of diver/hours	5	--	--	36	288	565	293	601
Catch/diver	**5**	--	--	**1.44**	**1.70**	**0.59**	**2.00**	**0.68**
Catch/diver-hour	**5**	--	--	**0.36**	**0.32**	**0.08**	**0.40**	**0.10**

* Probably more than one kind.

[1] Submitted for publication December 1966.

During 1963 and 1964, the Department of Fish and Game received catch records from 612 skindiving charters, 10 from central California and 602 from southern California. Central California charter boat operators reported that 149 divers took 178 fish and shellfish (Table 1) during the 10 skindiving trips in that region. Eight of the 10 trips were made in the Monterey Peninsula area; no reports were received from the Farallon Islands, the most frequented area in 1960–62.

Southern California charter boat operators reported 10,604 divers taking 27,031 fish, shellfish, and crustaceans, of at least 21 kinds (Table 2). The four principal species, abalone, kelp bass, lobster, and sheephead, have not varied in their relative importance during the past 7 years. Rock scallops moved from 16th to 5th in importance; this was the only major change from the preceding 3 years.

TABLE 2

Marine Species Taken by Charter Divers off Southern California 1963 and 1964

Common name	Number reported		
	1963	1964	Total
Abalone*	5,881	9,543	15,124
Kelp bass	2,262	1,995	4,257
Spiny lobster	998	2,115	3,113
California sheephead	983	1,221	2,204
Rock scallop	591	292	883
Opaleye	233	259	492
Perch*	34	251	285
California halibut	49	78	127
Rockfish*	68	56	124
Pacific bonito	13	14	27
California yellowtail	10	9	19
Halfmoon		16	16
Cabezon	2	14	16
Sculpin	12	2	14
Flatfish*	7	6	13
Lingcod	1	6	7
White seabass		4	4
California barracuda	2	1	3
Pacific mackerel	2		2
Ocean whitefish		1	1
Total	11,148	15,883	27,031
Number of trips	296	306	602
Number of divers	5,067	5,537	10,604
Number of diver-hours	23,831	26,526	50,357
Catch/diver	**2.20**	**2.87**	**2.55**
Catch/diver-hour	**0.47**	**0.60**	**0.54**

* Probably more than one kind.

The most favored diving areas in southern California were Santa Catalina, Santa Cruz, and Anacapa islands. These areas normally provide favorable diving conditions and results, and are easily reached from mainland ports.

TABLE 3

Marine Species Catch and Effort by Diving Area, Southern California, 1963 and 1964

Common name	Catch by area									
	Santa Catalina Island	Santa Cruz Island	Anacapa Island	Palos Verdes Peninsula	Santa Barbara Island	San Miguel Island	San Clemente Island	Santa Rosa Island	Dana Point	Total
Abalone*	10,573	2,937	1,228		151	60	125	50	--	15,424
Kelp bass	964	2,080	1,043	50	81	--	35	--	1	4,257
Spiny lobster	515	1,470	451	--	602	--	75	--	--	3,113
California sheephead	929	719	318	--	130	6	50	22	--	2,204
Rock scallop	152	398	80	238	--	8	--	7	--	883
Opaleye	11	335	116	--	--	--	--	--	--	492
Perch*	245	31	6	--	--	--	--	--	--	285
California halibut	114	7	1	--	3	1	1	--	--	127
Rockfish*	5	60	32	--	--	27	--	--	--	124
Pacific bonito	1	22	2	--	--	--	2	--	--	27
California yellowtail	12	7	--	--	--	--	--	--	--	19
Halfmoon	16	--	--	--	--	--	--	--	--	16
Cabezon	14	2	--	--	--	--	--	--	--	16
Sculpin	12	1	1	--	--	--	--	--	--	14
Flatfish*	--	10	3	--	--	--	--	--	--	13
Lingcod	1	5	--	--	--	1	--	--	--	7
White seabass	2	1	--	--	1	--	--	--	--	4
California barracuda	1	1	1	--	--	--	--	--	--	3
Pacific mackerel	2	--	--	--	--	--	--	--	--	2
Ocean whitefish	1	--	--	--	--	--	--	--	--	1
Total	13,570	8,089	3,342	288	1,268	103	288	79	4	27,031
Number of trips	387	114	59	23	11	3	2	2	1	--
Number of divers	6,610	2,204	1,075	337	231	42	54	44	7	--
Number of diver-hours	31,603.5	10,927.5	4,814	1,348	979.0	165.0	245.0	240.0	35.0	--
Catch per diver	**2.05**	**3.67**	**3.11**	**0.85**	**5.49**	**2.45**	**5.33**	**1.80**	**0.57**	--
Catch per diver-hour	**0.43**	**0.74**	**0.69**	**0.21**	**1.30**	**0.62**	**1.18**	**0.33**	**0.11**	--

* Probably more than one kind.

Divers at Santa Catalina Island took 68% of the 1963–1964 abalone catch, while at Santa Barbara Island 2.2% of the total divers took 19.3% of the total lobster catch (Table 3). Anacapa and Santa Cruz islands were the best all around diving areas: here, 31% of the divers took 27% of the abalones, 73% of the kelp bass, 62% of the lobsters, and 48% of the sheephead.

A single boat reported 23 trips to the Palos Verdes Peninsula. Of the 337 divers logged on these trips, perhaps half were trainees. For this reason, the low catch of 0.21 animals per diver-hour was probably a small fraction of the true potential.

According to the 1963–1964 logs, southern California divers averaged 4.75 hours diving time per trip. However, this figure includes most, if not all, of the time boats were at anchor. The actual underwater dive time depends largely upon the number of air tanks available but, in any case, it is less than the time at anchor. On trips on which there are a large number of divers, much time may be spent on deck waiting for air tanks to be recharged. On one trip, for example, 17 divers reported using an average of four tanks each with 30 minutes diving time per tank (total possible = 2 hours), while the boat log showed 5 hours of diving time.

TABLE 4

Common and Scientific Names of Marine Species Taken by Charter Divers in California, 1963 and 1964

Common name	Scientific name
Fishes	
Bass, kelp	*Paralabrax clathratus*
Barracuda, California	*Sphyraena argentea*
Bonito, Pacific	*Sarda chiliensis*
Cabezon	*Scorpaenichthys marmoratus*
Flatfish*	Species of bothids and pleuronectids
Halfmoon	*Medialuna californiensis*
Halibut, California	*Paralichthys californicus*
Lingcod	*Ophiodon elongatus*
Mackerel, Pacific	*Pneumatophorus diego*
Opaleye	*Girella nigricans*
Perch*	Species of embiotocids
Rockfish*	*Sebastodes spp.*
Sculpin	*Scorpaena guttata*
Seabass, white	*Cynoscion nobilis*
Sheephead, California	*Pimelometopon pulchrum*
Ocean whitefish	*Caulolatilus princeps*
Yellowtail, California	*Seriola dorsalis*
Mollusks	
Abalone*	*Haliotis spp.*
Scallop, rock	*Hinnites multirugosus*
Crustaceans	
Lobster, spiny	*Panulirus interruptus*
Echinoderms	
Sea urchins	*Strongylocentrotus franciscanus*

* Probably more than one kind.

Southern California divers averaged 2.55 fish, shellfish, and crustaceans per day in 1963–1964, very similar to the 2.4 animals per day obtained in 1960–1962. Furthermore, Anacapa and Santa Cruz island divers averaged 3.1 and 3.7 animals during 1963–1964, compared with the 1960–1962 average of 3.0 and 3.6 animals. At Santa Catalina Island, catches increased from 1.75 animals in 1960–1962, to 2.05 animals per diver in 1963–1964.

REFERENCES

State of California. 1963. Fish and Game Code, 43rd ed., 294 p.

Wood, William E. 1964. Partyboat logs show how skindivers fared during 1960, 1961, and 1962. Calif. Fish and Game, 50 (2) : 114–117.

Young, Parke H. 1961. Partyboat logs show how skindivers fared during 1958 and 1959. Calif. Fish and Game, 47 (3) : 303–305.

Calif. Fish and Game, 53 (3) : 197-202. 1967.

SEROLOGICAL STUDIES OF KELP BASS, *PARALABRAX CLATHRATUS*[1]

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This is the first report of human blood-typing sera agglutinating kelp bass erythrocytes, and of kelp bass sera clumping human red cells. Fish sera from one species have not previously been known to contain agglutinins specific against all human red cells in the ABO system.

Agglutination frequencies of kelp bass erythrocytes in human A and B blood-typing sera were compared in fish caught near the southern California mainland and at Santa Catalina Island. A statistically significant difference in agglutination frequencies in B typing serum indicated separate populations.

Additional blood tests revealed that there was no correlation between type of bass serum agglutinin and agglutinogen present, and that the kelp bass sera contained both specific and nonspecific agglutinins against human type O red cells.

INTRODUCTION

Genetically distinct populations of marine vertebrates have been identified by comparing the agglutination frequencies of their red blood cells in a specific reagent. This method was utilized in studying sei, fin, blue, and humpback whales (Fujino, 1953); sockeye salmon (Ridgway, Cushing, and Durall, 1958); albacore (Suzuki, Morio, and Mimoto, 1959); fur seals (Fujino and Cushing, 1960); spiny dogfish (Sindermann and Mairs, 1961); Pacific sardines (Sprague and Vrooman, 1962); albacore, bigeye tuna, skipjack, and yellowfin tuna (Sprague, Holloway, and Nakashima, 1962); and golden, rainbow, cutthroat, brown, and brook trout (Calaprice and Cushing, 1964). Such investigations have been described in detail (Cushing, 1964).

Fish sera contain a variety of substances which agglutinate erythrocytes. Within a species, serum agglutinins occur in different frequencies. This has been demonstrated in the eel *Anguilla anguilla* (Grubb, 1949); yellowfin tuna and skipjack (Cushing, 1952*a*,*b*); dolphin (Yamaguchi and Fujino, 1953); goldfish (Hildemann, 1956); and catfish, white croaker, and skipjack (Cushing and Durall, 1957). However, no one has studied agglutinin frequencies to see if they could be used in identifying noninterbreeding populations. This is probably because certain agglutinins might have been introduced previously by infections, and because some may appear in the serum only seasonally. Therefore, it would be difficult to tell if a particular agglutinin represents a genetic character or an environmentally induced one.

Identification of separate kelp bass populations is an essential requisite for managing the resource. The present research was designed to determine if two geographically divided groups of bass are genetically distinct. I investigated the frequency of agglutination of their red

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cells in human A and B blood-typing sera, and compared bass agglutinin frequencies with the genetically-based agglutinogen frequency, to see if a systematic relationship existed.

METHODS

Kelp bass were caught by hook and line, and individually examined for evidence of disease and infestation. Healthy-looking fish were blotted dry with a towel and bled by severing the caudal peduncle with a sharp knife; approximately 2 ml of blood from each fish was collected directly into separate vials.

Fish erythrocytes to be tested were prepared aboard ship from the blood which had been mixed with 3 to 5 crystals of sodium citrate (anticoagulant). Sufficient physiological saline solution (0.9 grams sodium chloride in 100 ml distilled water) was added to one drop of this treated blood from each fish to make a 2% suspension of cells. The required dilution was obtained by comparing its color with a "standard" 2% suspension. Next, the vials of blood cell suspensions were corked and refrigerated for use within 24 hours.

Fish sera for testing also were prepared aboard ship. Whole blood was refrigerated for several hours, after which the clot was removed from each vial with a wooden applicator. At the laboratory the remaining serum was cleared by centrifugation for 5 minutes at 1,000 r.p.m., and the sample then stored frozen until needed.

The experiments were performed with red blood cells and sera, and utilized agglutination tests and absorption tests. These were performed in 10x75 mm test tubes, and on 10-concavity agglutination slides.

Agglutination Test I. Fish Cells—Human Typing Sera [3]

Two drops of typing serum were added to one drop of 2% red cell suspension. The mixture was then thoroughly shaken and covered to prevent evaporation. After 1 hour at room temperature, it was read and assigned agglutination values 1+ through 4+; a rating of 1+ was assigned to cell clumping just faintly visible to the naked eye, while 4+ was used only for strongest reactions.

Agglutination Test II. Fish Sera—Human Cells

Two drops of bass serum diluted 1:2 with physiological saline were added to two drops of a 2% suspension of washed erythrocytes [4] (type A, B, or O). The mixture was then treated as in Test I.

Absorption Test

This test was modified slightly from that recommended by Cushing (1952*b*). One ml of fish serum from each individual was diluted 1:2 with physiological saline and placed in test tubes containing 0.1 ml of packed, human type O cells. The tubes were then corked, shaken horizontally for 5 to 8 minutes, and centrifuged. Next, the supernatent was decanted for testing against human A, B, and O cells as in Test II.

[3] Ortho Laboratory human A and B blood-typing sera.
[4] Obtained fresh for each test from Memorial Hospital, Long Beach, California.

RESULTS

Agglutination frequencies of fish red cells in human A and B sera were compared in kelp bass caught near the southern California mainland (Corona del Mar to Dana Point) and at Santa Catalina Island (White's Cove)—locales approximately 40 miles apart. Of 107 mainland bass, 5 reacted in A typing serum and none in B serum. Of 126 Santa Catalina Island fish, 9 reacted in A typing serum and 13 in B serum (Table 1). Differences in the frequencies of red cell agglutination in B typing serum were statistically significant at the 95 and 99% confidence limits, indicating that the kelp bass in each locale belong to a separate population.

TABLE 1

Comparison of the Agglutination Frequencies of Kelp Bass Red Cells in Human A and B Typing Sera

Degree of agglutination	Number of agglutinations			
	Mainland kelp bass		Santa Catalina I. kelp bass	
	A Typing serum	B Typing serum	A Typing serum	B Typing serum
1+	2	0	0	1
2+	0	0	0	4
3+	2	0	6	3
4+	1	0	3	5
Totals	**5**	**0**	**9**	**13**

Blood samples from the first 60 of the bass caught at Santa Catalina Island were tested reciprocally, using both Tests I and II (Table 2). I found that A and B, or B agglutinogen existed in certain of these fish and that agglutinins were present with little respect to type of agglutinogen present. For example, erythrocytes from fish nos. 4, 5, 24, 37, and 55 agglutinated in human B typing serum, while the sera of these fish had no detectable agglutinins. However, red cells from fish no. 23 likewise agglutinated only in B typing serum, but the bass serum contained A, B, and unknown (i.e., type O cell-clumping) agglutinins. In other instances, red cells from specimen no. 16 agglutinated in A and B typing sera, while the fish serum agglutinated human type B and O erythrocytes; cells from specimens 38 and 51 likewise agglutinated in A and B typing sera, but their own sera apparently lacked agglutinins. Red cells from the remaining bass did not agglutinate in A or B typing sera; however, the sera from this group contained a variety of agglutinins. These ranged from A (no. 35), B (nos.

1, 25, 50, and 58), unknown agglutinins (nos. 8 and 59), A and B (no. 33), B and unknown agglutinins (no. 30), through A, B, and unknown agglutinins (nos. 6, 7, 12, 13, 17, 18, 23, 43, and 52). In addition, sera from kelp bass nos. 8 and 59 contained agglutinins specific against human type O cells.

TABLE 2

Results of Testing Kelp Bass Red Cells with Human Typing Sera (A and B), and Kelp Bass Sera with Human Red Cells (Types A, B, and O)

Specimen number	Bass cells—human typing serum		Bass serum—human cells		
	A	B	A	B	O
1	0	0	0	3+	0
2, 3	0	0	0	0	0
4, 5	0	2+	0	0	0
6	0	0	4+	4+	4+
7	0	0	3+	1+	3+
8	0	0	0	0	2+
9–11	0	0	0	0	0
12	0	0	2+	3+	3+
13	0	0	4+	3+	4+
14, 15	0	0	0	0	0
16	3+	3+	0	2+	1+
17	0	0	3+	3+	3+
18	0	0	3+	2+	3+
19–22	0	0	0	0	0
23	0	1+	4+	4+	3+
24	0	3+	0	0	0
25	0	0	0	3+	0
26–29	0	0	0	0	0
30	0	0	0	1+	3+
31, 32	0	0	0	0	0
33	0	0	3+	2+	0
34	0	0	0	0	0
35	0	0	3+	0	0
36	0	0	0	0	0
37	0	3+	0	0	0
38	3+	4+	0	0	0
39–42	0	0	0	0	0
43	0	0	3+	3+	3+
44–49	0	0	0	0	0
50	0	0	0	2+	0
51	3+	2+	0	0	0
52	0	0	4+	4+	4+
53, 54	0	0	0	0	0
55	0	4+	0	0	0
56, 57	0	0	0	0	0
58	0	0	0	2+	0
59	0	0	0	0	1+
60	0	0	0	0	0

Sera from nine of the 60 kelp bass from Santa Catalina Island agglutinated human type A, B, and O erythrocytes. Absorption tests performed on three of these confirmed that agglutinins specific against type O cells were present in specimen no. 52 (Table 3). Antibodies specific against human type O red cells previously were described in sera of the eel *Anguilla anguilla* (Grubb, 1949).

TABLE 3
Results of Testing Kelp Bass Sera (unabsorbed and absorbed) with Human Type A, B, and O Red Cells

Specimen number	Bass serum (unabsorbed) with human cells			Bass serum (absorbed) with human cells		
	A	B	O	A	B	O
52	4+	4+	4+	2+	2+	0
18	3+	2+	3+	0	0	0
23	4+	4+	3+	0	0	0

The absorption tests, in addition, demonstrated that kelp bass sera contained nonspecific agglutinins that reacted against type O cells (specimens no. 18 and 23, Table 3). These nonspecific agglutinins were anti-A and -B because they also reacted with the type A and B cells. They were revealed by their depletion from the fish sera after being exposed to type O red cells.

In 1935, S. Sugishita reported that serum of the eel *A. japonica* reacts against all types of human erythrocytes (Cushing, 1964), but the specificity of the agglutinins apparently was not determined.

SUMMARY AND CONCLUSIONS

This is the first report of kelp bass erythrocytes being agglutinated by human blood-typing sera, and of kelp bass sera clumping human red cells. Fish sera from a single species have not previously been known to contain agglutinins specific against all human red blood cells in the ABO system.

The agglutination frequencies of kelp bass red cells in commercial human A and B blood-typing sera were compared in fish caught near the southern California mainland and at Santa Catalina Island. A significant difference in agglutination frequencies in B typing serum lead to the conclusion that there is a separate bass population in each locale.

"Reciprocal" testing of kelp bass and human bloods (commercial human typing sera were used) showed in bass that the presence of a particular agglutinogen did not positively mean the reciprocal agglutinin was present in the serum; agglutinins seemed to follow no rule as to type present or absent. Therefore, I concluded that the agglutinin frequencies in kelp bass were not systematically related to their agglutinogen frequencies, which have a genetic basis.

On the basis of reciprocal and absorption tests of kelp bass sera capable of agglutinating human type A, B, and O red cells, the fish sera could be divided into two groups: one contained specific, and the other nonspecific, agglutinins that react with human type O cells. The nonspecific agglutinins were designated anti-A and -B, since they also reacted against type A and B red cells, respectively; these agglutinins were revealed by their depletion from fish sera exposed to type O red cells.

ACKNOWLEDGMENTS

I would like to extend my sincere thanks to Harold B. Clemens for his helpful criticism of the manuscript.

REFERENCES

Calaprice, J. R., and J. E. Cushing. 1961. Erythrocyte antigens of California trout. Calif. Fish and Game, 50 (3) : 152–157.

Cushing, J. E. 1952*a*. Serological differentiation of fish bloods. Science, 115 (2989) : 404–405.

———— 1952*b*. Individual variation in the hemagglutinin content of yellowfin tuna and skipjack bloods. Jour. Immunol., 68 (5) : 543–547.

———— 1961. The blood groups of marine animals. p. 85–131. *In* F. S. Russell [ed.]. Advances in marine biology, Vol. 2. Academic Press, New York.

Cushing, J. E., and G. L. Durall. 1957. Isoagglutination in fish. Amer. Nat., 91 (857) : 121–126.

Fujino, K. 1953. On the serological constitution of the sei-, fin-, blue- and humpback-whales. 1. Whales. Res. Inst., Sci. Repts., (8) : 103–124.

Fujino, K., and J. E. Cushing. 1960. Blood types in fur seals. Science, 131 (3409) : 1310.

Grubb, R. 1949. Some aspects of the complexity of human ABO groups. Acta Pathol. Microbiol. Scand., Suppl., 84 : 1–72.

Hildemann, W. H. 1956. Goldfish erythrocyte antigens and serology. Science, 124 (3216) : 315–316.

Ridgway, G. W., J. E. Cushing, and G. L. Durall. 1958. Serological differentiation of populations of sockeye salmon, *Oncorhynchus nerka*. U.S. Fish and Wildl. Serv., Spec. Sci. Rept.: Fish. (257) : 1–9.

Sindermann, C. J., and D. F. Mairs. 1961. A blood group system for spiny dogfish, *Squalus acanthias* L. Biol. Bull., 120 (3) :401–410.

Sprague, L. M., and A. M. Vrooman. 1962. A racial analysis of the Pacific sardine (*Sardinops caerulea*) based on studies of erythrocyte antigens. Ann. N. Y. Acad. Sci., 97 : 131–138.

Sprague, L. M., J. R. Holloway,and L. I. Nakashima. 1962. Studies of the erythrocyte antigens of albacore, bigeye, skipjack and yellowfin tunas and their use in subpopulation identification. FAO World Sci. Meet. Biol. Tunas and Related Species, La Jolla, Calif., Sec. 2. Experience paper, (22) : 1–15.

Suzuki, A., T. Morio, and K. Mimoto. 1959. Serological studies of the races of tuna. 2. Blood group frequencies of the albacore in Tg-system. Pt. 1. Comparison of the Indian and northwestern Pacific Ocean. Nankai Reg. Fish. Res. Lab., Rept., (11) : 17–23.

Yamaguchi, K., and K. Fujino. 1953. On the serological constitution of the striped dolphin, *Prodelphinus caeruleo-albus* (Meyen). Japan Acad., Proc. 29 (2) : 61–67.

Calif. Fish and Game, 53 (3) : 203-208, 1967.

AN INEXPENSIVE, SELF-CONTAINED UNDERWATER DATA RECORDING CAMERA[1]

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An inexpensive data recording camera with underwater housing designed for shallow water use is described. The unit requires no tending while in operation and will operate for long periods of time.

A great deal of photographic equipment has been designed and constructed to use underwater where direct observation was infeasible. Most of this equipment has been designed to operate in deep water (Edgerton and Hoadley, 1955; Kruse, 1964). To construct equipment of this type, highly skilled personnel and considerable expense are required.

The recording camera with underwater housing described here is designed for shallow water (less than 50 feet), is relatively easy to fabricate, and can be constructed for less than $125. The basic design is readily adaptable for laboratory or field studies in which it is necessary to monitor equipment or organisms underwater. The unit requires no tending while in operation and will operate for long periods of time.

CAMERA

A data recording camera for use underwater must fulfill a number of requirements. It must be relatively compact, take a large number of single-frame photographs without service, have an adjustable lens, and load easily and rapidly.

Although many recording cameras have these features, their cost of $1,000 or more limits their usage, especially when the likelihood of loss is high or when several units are desired.

A number of 16-millimeter, magazine-load, motion picture cameras also fill these requirements. Examples are the Bell and Howell 200 and Automaster, Revere Sixteen Magazine Load, Cine-Kodak Royal Magazine, and the Silver Star 16-millimeter Sequence and Movie Camera.[2] When new, these cameras range in price from $170 to $300, but used models are plentiful and can be purchased for $25 to $75. The magazines hold 50 feet of film and are available in black-and-white and color.

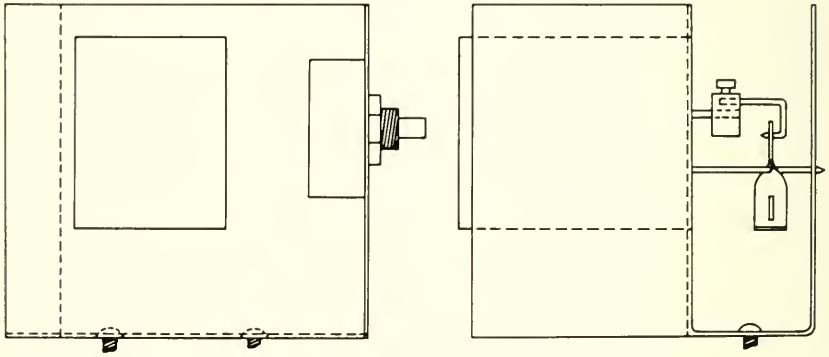
The camera is spring-driven and permits exposure of 10 to 15 feet of film on a single wind, or when rewound while submerged, the entire film load. Exposing 10 feet of film provides 400 individual frames (there are 40 frames per foot on 16-millimeter film), or at one frame per minute, enough film to monitor for slightly over 6½ hours.

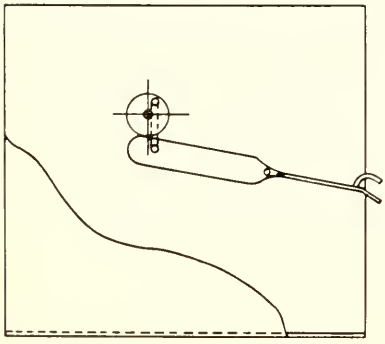
[1] Submitted for publication February 1967.
[2] Use of trade names does not imply endorsement of the products.

TRIPPING MECHANISM

In setting up the camera tripping mechanism, the shutter-release trip lever is driven through a connecting rod and eccentric wheel attached to the drive shaft of a 3-volt D.C. electric display motor (Figures 1 and 2). The camera and tripping assembly are fastened to a $\frac{1}{4}$-inch plastic plate (Figure 3) with brass machine screws. The plate slides into the housing under two runners.

The motor is powered by two class-D dry-cell batteries. These motors are small, but durable, and are available in speeds from 1 to 150 rpm with battery holder and leads attached. Although the battery life varies with load requirements, units have run as long as 480 hours without battery replacement. We have used a motor rated at approximately 1 rpm. However, with the installation of a 5-watt, 100-ohm potenti-





CUT-AWAY OF LEFT SIDE
SHOWING LEVER ARRANGMENT

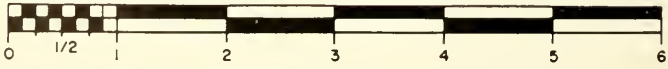


FIGURE 1—Tripping mechanism for the Bell and Howell 200 motion picture camera.

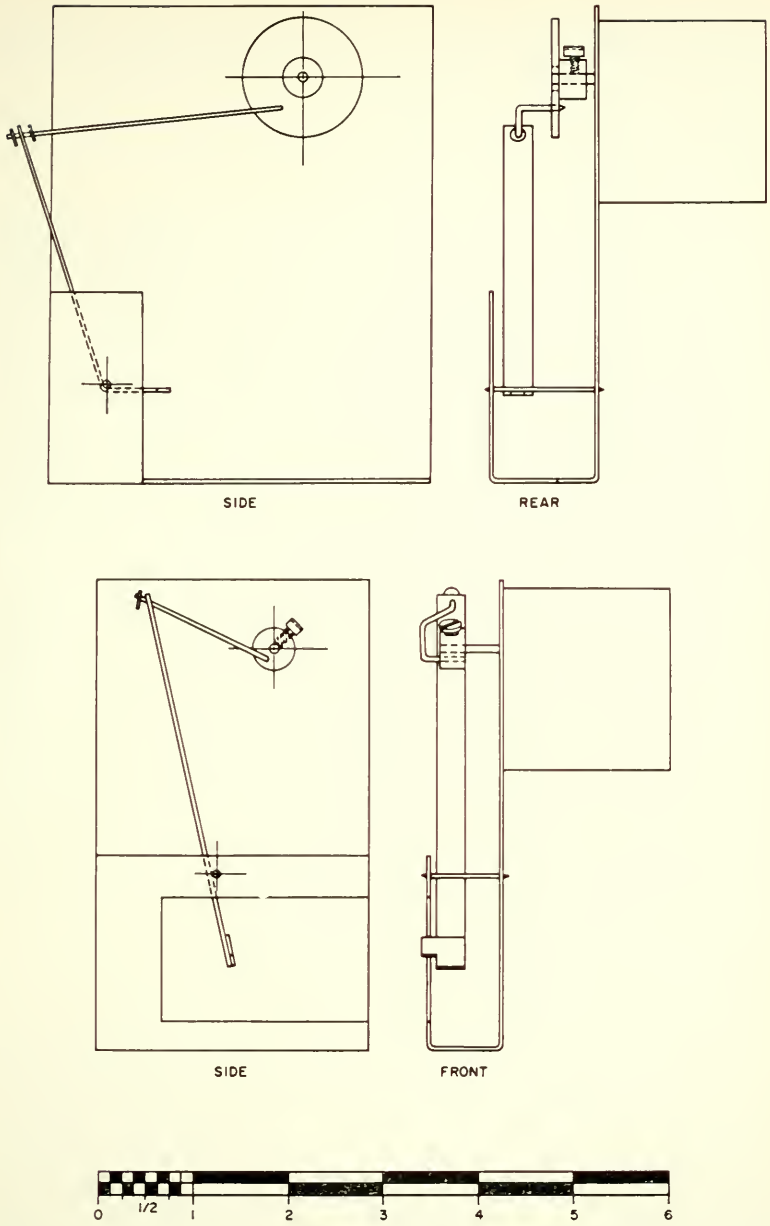


FIGURE 2—Above—Tripping mechanism for the Bell and Howell Automaster motion picture camera. Below—Tripping mechanism for the Revere Sixteen Magazine Load motion picture camera.

ometer and a 0–3-volt D.C. voltometer, it is possible to regulate the speed of the motor from 0.5–2 rpm (1 revolution = 1 shutter release). A slight voltage drop (0.2 volts per 8-hour period) which occurred during continuous running, lengthened the interval between frames, and decreased the total frames exposed in an 8-hour observation period by about 4%. The loss in total frames could have been eliminated by periodically adjusting the potentiometer.

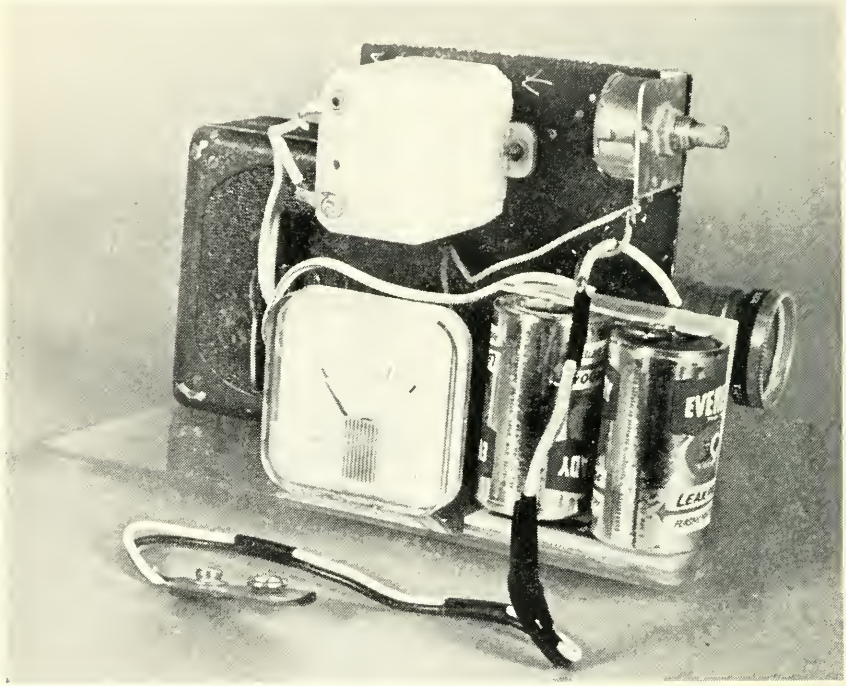


FIGURE 3—Camera and tripping mechanism ready to be installed in housing. Note snaps for disconnecting tripping mechanism from front plate "switch".

UNDERWATER HOUSING AND CONTROLS

The camera housing is of clear acrylic plastic (Toggweiler, 1962). Acrylic plastic is easily worked, has excellent light transmitting qualities, and allows one to observe the internal equipment and detect water leaks. It can be cemented with ethylene dichloride solvent (Rohm and Haas Company, 1964).

The housing is of tubing 8 inches in diameter with $\frac{1}{4}$-inch wall, sealed at one end with $\frac{3}{8}$-inch sheet stock (Figure 4). The front edge of the tubing is grooved to hold a $\frac{1}{8}$-inch diameter "O" ring for sealing the removable front plate. The front plate of $\frac{3}{8}$-inch sheet stock is cut $\frac{1}{16}$-inch larger than the outside diameter of the tubing and has six equally-spaced "lobes" 1-inch in radius. The lobes are drilled to accommodate retaining studs. A piece of tubing 4 inches in diameter, $\frac{1}{2}$-inch long, with $\frac{1}{8}$-inch wall is cemented to the outside of the front plate to provide protection from scratching and is painted flat black with acrylic paint to eliminate undesirable light reflections.

To attach the front plate, six equally-spaced stud retainers, $\frac{3}{4}$ by $1\frac{1}{2}$ inches, are cemented to the outside of the housing along the front edge. These are then threaded to receive $\frac{1}{4}$-by-1-inch brass studs with wing nuts.

The external controls for the camera wind and potentiometer are sealed with an "O" ring. These are available from most diving equipment suppliers (Toggweiler, 1962). The control for the potentiometer enters through the front plate and connects with the adjustment screw on the potentiometer. A frictional adapter made from a rubber bottle stopper, drilled at the ends, is used to connect the control shaft and adjustment screw. The camera wind control enters through the right side of the housing on center with the camera's wind shaft. A fork of $\frac{1}{8}$-inch stainless steel rod, attached to the end of the control shaft, is fitted over the erected camera wind key. A large external knob was used on this control because considerable leverage is necessary to wind most spring-driven cameras.

Waterproof plugs installed in the front plate (Figure 4) are used as a simple "on-off" switch that can be operated without opening the housing. Wires leading from the switch to the tripping mechanism have snaps so the mechanism can be disconnected from the front plate when servicing the camera.

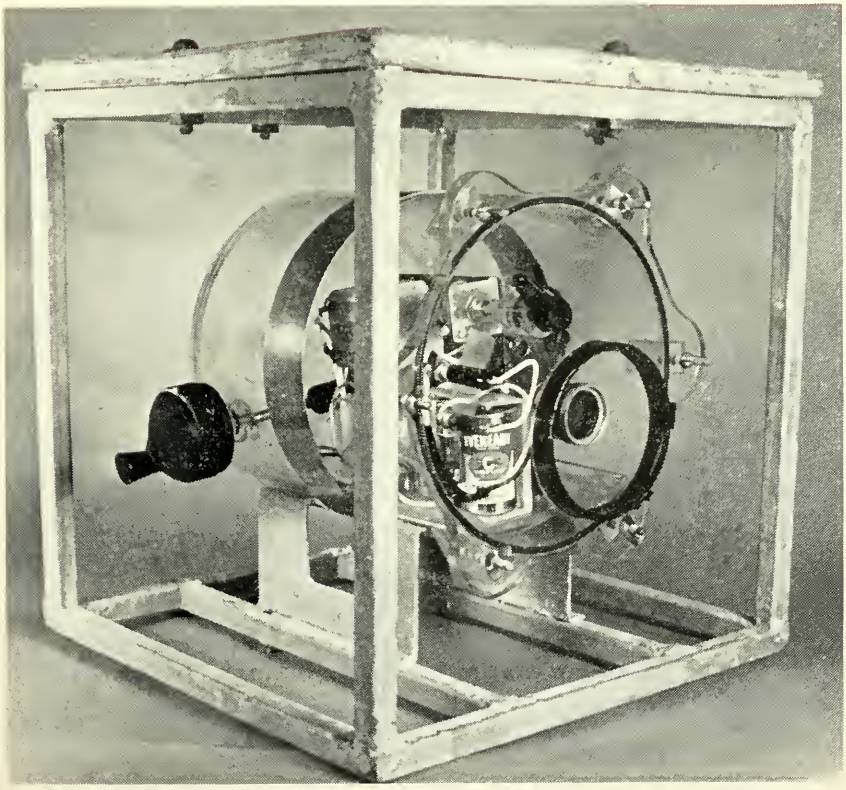


FIGURE 4—Data recording camera within protective framework ready for submergence.

A tubing framework, 13 x 12 x 13 inches of $\frac{1}{2}$-inch square aluminum, is used to protect the camera housing and provide a point of attachment for a holding stanchion. The housing rests in a sheet-aluminum cradle within the framework and is held in place by a 2-inch adjustable stainless steel band cushioned with neoprene rubber.

All "O" rings are coated with silicone grease before each submergence to insure a waterproof seal. A small porous container of silica gel dessicant is placed in the housing to provide a dry atmosphere for the camera and timing assembly.

The camera lens is provided with a shade that extends to the front plate. This eliminates light reflections originating from within the housing.

When associated with the U. S. Bureau of Commercial Fisheries, Tuna Resources Laboratory, La Jolla, California, I successfully used cameras of this design in evaluating the relative abundance of fishes attracted to objects moored in the open sea. A correlation coefficient of 0.733 (significant at 0.001) was obtained comparing daily estimates by divers and the percentage of total film frames containing fish on the same days. The cameras were used, with a minimum of maintenance, daily over a period of 2 months.

REFERENCES

Edgerton, Harold E., and Lloyd D. Hoadley. 1955. Cameras and lights for underwater use. Jour. Motion Picture and Television Eng., 64 : 345–350.

Kruse, Paul J. 1964. A remote controlled underwater photographic surveillance system. U. S. Fish and Wildl. Serv., Spec. Sci. Rept., Fish. 490 : 16 p.

Rohm and Haas Company. 1964. Plexiglass sheet-cementing. Bull. PL-7h, 19 p. *In* Plexiglass design and fabrication data. Rev. ed. Philadelphia.

Toggweiler, Mart. 1962. How to build your own underwater camera housing. Dive-Rite Products, Box 14444, Long Beach, Calif., 73 p.

NOTES

TAGGED ANCHOVIES MOVE FROM SOUTHERN CALIFORNIA TO MONTEREY BAY

On March 14, 1966, the California Department of Fish and Game began tagging and releasing northern anchovies (*Engraulis mordax* Girard) with small, internal, metal tags (Vrooman, Paloma, and Jordán, 1966). These tags are recovered by magnets placed in cannery reduction lines.

During the reduction season, which closed April 30, 1966, 22,955 fish were tagged and 138 recovered. Additional tagging and recoveries have since brought the totals to 100,509 fish tagged and 253 recovered.

Tag recoveries include four of great significance. A fish tagged March 17 off Point Fermin was recovered in Monterey Bay October 25. Two fish tagged off Point Hueneme April 6 were recovered in Monterey Bay on October 21 and 26, respectively, and one tagged off Santa Catalina Island on April 26 was recovered in Monterey Bay on January 4, 1967. The Point Fermin and Santa Catalina Island to Monterey Bay recoveries represent a direct-line migration of 350 miles in 223 and 253 days, respectively. The other two traveled at least 275 miles in 199 and 204 days, respectively.

LITERATURE CITED

Vrooman, Andrew M., Pedro A. Paloma, and Rómulo Jordán. 1966. Experimental tagging of the northern anchovy, *Engraulis mordax*. Calif. Fish and Game, 25 (4) : 228–239.

—*J. D. Messersmith, Marine Resources Operations, California Department of Fish and Game, January 1967.*

FINAL INTRODUCTIONS OF THE BONNEVILLE CISCO (*PROSOPIUM GEMMIFERUM* SNYDER) INTO LAKE TAHOE, CALIFORNIA AND NEVADA

In January of 1964, 1965, and 1966, spawning Bonneville cisco were collected from Bear Lake, Utah-Idaho, and transported to Lake Tahoe. Reasons for the introduction, a description of the cisco, and details of the 1964 program were presented by Frantz and Cordone (1965). In all, 15,888 cisco were released over the three years (Table 1).

TABLE 1

Bonneville Cisco Planted in Lake Tahoe

Year	Number collected and transported	Transportation loss	Released alive
1964	8,500	3,000	5,500
1965	7,906	2,614	5,292
1966	5,100	4	5,096
Totals	21,506	5,618	15,888

Losses during transportation were reduced to an insignificant level in 1966, following high losses in 1964 and 1965. This reduction was attributed to more careful handling, maintaining temperatures in the tank between 34 and 40 instead of between 42 and 50°F., and reducing the concentration of fish in the tank from between 4.7 and 7.1 to about 3.5 per gallon.

In addition to the ripe adults, an estimated 250,000 eggs were artificially taken and fertilized at Bear Lake during the three collection years. About 205,000 were released directly into shallow rocky areas in Lake Tahoe. The remainder were held at Nevada's Verdi Fish Hatchery, and those that survived were released later as eyed eggs (25,000) and alevins (3,000).

We wish to acknowledge the wholehearted support of the Utah State Department of Fish and Game and the Idaho Fish and Game Department. The assistance of Arnold Bangerter, Utah Fishery Biologist, was especially valuable.

LITERATURE CITED

Frantz, Ted C., and Almo J. Cordone. 1965. Introduction of the Bonneville cisco (*Prosopium gemmiferum* Snyder) into Lake Tahoe, California and Nevada. Calif. Fish and Game, 51 (4) : 270–275.

—*Ted C. Frantz, Nevada Fish and Game Commission, Reno, Nevada and Almo J. Cordone, Inland Fisheries Branch, California Department of Fish and Game, September 1966.*

A 1955 RECORD OF PINK SALMON, *ONCORHYNCHUS GORBUSCHA*, SPAWNING IN THE RUSSIAN RIVER

Definite records of pink salmon in California coastal streams are uncommon. Scofield (1916) reported "several" in the San Lorenzo River, Snyder (1931) listed it as present but rare in the Klamath River, and Smedley (1952) reported a specimen from Prairie Creek. The only report mentioning the Russian River was that of Taft (1938), who recorded an influx of some numbers of pink salmon in 1937 into the Russian, Garcia, and Ten Mile rivers and a single specimen taken in Mad River.

In the Sacramento River system, the species has been reported more often, the latest paper being that of Hallock and Fry (1967).

After some seasons of hearing occasional rumors of pink salmon in the Russian River, some Department of Fish and Game staff members made a one-day trip to the vicinity of Duncans Mills in 1953. Several gill net drifts were made near the upstream end of tidewater, but no salmon of any kind were obtained. However, while on this trip we talked to several people who told very convincing stories of encountering pink salmon.

On the weekend of October 8–9, 1955, a sportsman landed two pink salmon, a male and female, and took them to King's Sporting Goods Store in Guerneville. Mr. King, who had been arguing that there were pink salmon in the Russian River, was overjoyed to see them and promptly traded two larger king salmon for them. He then notified the Department of Fish and Game.

Charles Meacham, who was then with the Department, obtained the two salmon, then went to the spot where they had been caught, a riffle immediately downstream from the mouth of Austin Creek. He fished for about 2 hours but was unable to obtain any additional specimens, then started looking for carcasses and found four, two males and two females, all of which had apparently spawned and all of which had apparently been caught by snagging.

On October 14, 1955, the writer visited this same riffle and watched pink salmon spawning on at least six different nests. The gravel which was being used was fine and sandy by comparison with that in which king salmon normally spawn; the majority of the larger rocks were no more than 2 inches in greatest diameter. The riffle is a wide one, gravel in the center is coarser, but the pinks appeared to prefer the relatively fine material near the edges. Wading around in the middle of the riffle failed to disclose any nests in the coarse gravel.

The females would dig very briefly, then stop for a fairly protracted period. They frequently swam away from the redd and disappeared for a while. It is possible that they were made nervous by the presence of the writer and three anglers who were in the area. This tendency to dart about made it difficult to identify each female or each redd with certainty. There were, however, four nests which were very close to the bank and could be seen clearly.

The females were not accompanied by males while the digging was going on, but there were some males in the area.

One badly decomposed carcass (female) was found.

While the writer was watching the salmon, one angler hooked two of them, using either one or two salmon eggs on a single No. 12 hook. The first fish stayed hooked only a second or two but the other was played for considerable time and brought into shallow water almost completely exhausted. No gaff or landing net was available and the fish was lost in attempts to beach it. It had enough energy to work its way back to deep water. It was a female of perhaps 5 pounds. The angler in question was fishing for (and catching) small trout.

REFERENCES

Hallock, Richard J., and Donald H. Fry, Jr. 1967. Five species of salmon, *Oncorhynchus*, in the Sacramento River, California. Calif. Fish and Game, 53 (1) : 5–22.

Scofield, N. B. 1916. The humpback and dog salmon taken in San Lorenzo River. Calif. Fish and Game, 2 (1) : 41.

Smedley, S. C. 1952. Pink salmon in Prairie Creek, California. Calif. Fish and Game, 38 (2) : 275.

Snyder, John O. 1931. Salmon of the Klamath River, California. Calif. Div. Fish and Game, Fish Bull., (34) : 130 p.

Taft, A. C. 1938. Pink salmon in California. Calif. Fish and Game, 24 (2) : 197–198.

—Donald H. Fry, Jr., Marine Resources Branch, California Department of Fish and Game, July 1966.

A HIGH PHEASANT *(PHASIANUS COLCHICUS)* NEST DENSITY ON THE GRAY LODGE WATERFOWL MANAGEMENT AREA

On June 3, 1966, a fire originating on private property spread onto the Gray Lodge Waterfowl Management Area, burning 110 acres. Gray Lodge is in southern Butte County, at approximately the center of the Sacramento Valley. An extremely dry spring had produced flammable conditions much earlier than normal. The height of the nesting season and the completeness of the burn presented a unique opportunity to survey pheasant nest density and note any loss of wildlife.

The burned area was in good pheasant habitat (Figure 1). Original vegetative cover was primarily yellow star thistle *(Centaurea solstitialis)*, foxtail *(Hordeum murinum)*, canary grass *(Phalaris canariensis)*, rye grass (*Lolium* sp.), and wild oat *(Avena fatua)*. Patches of tule *(Scirpus acutus)*, cattail (*Typha* sp.), and bulrush (*Scirpus* sp.) were present. Willow (*Salix* sp.) and Fremont cottonwood *(Populus fremontii)* trees were scattered over the area.

FIGURE 1—View of the edge of the burned area, Gray Lodge Waterfowl Management Area. *Photograph by John B. Cowan, June 1966.*

The entire burn was systematically searched for pheasant nests and any evidence of wildlife losses noted. One hundred fifty-four nests were found, representing a density of 1.4 per acre. All nests in the burn were destroyed. Examination revealed the following: 33 (21%) were in incubation or in process of hatching, 29 (19%) had hatched before the burn, 36 (23%) had been destroyed by predators, and 56 (37%) were dump nests, abandoned nests, incomplete clutches, or of unknown status.

The 29 nests which had hatched before the fire showed 9.0 eggs per clutch and a hatch of 7.5 (83%). Previous nest studies at Gray Lodge had shown higher clutch sizes, ranging in various years from 10.7 to 12.9. The 1966 clutch size of 9.0 may be a reflection of the extremely dry spring, which is generally considered unfavorable for pheasant nesting.

Pheasant losses were confined to newly hatched chicks at four nests and two juvenile birds. The only other wildlife losses were a California quail *(Lophortyx californicus)* nest containing 12 eggs and one black-tailed jackrabbit *(Lepus californicus)*.

Many pheasants immediately returned to the burned area and in two cases hens attempted to resume incubation on the destroyed nests.—*Jonathan H. Ives and John B. Cowan, Wildlife Management Branch, California Department of Fish and Game, October 1966.*

ISOLATION OF *PASTEURELLA MULTOCIDA* FROM A SNOWY OWL (*NYCTEA SCANDIACA*), A NEW HOST RECORD

On January 4, 1967, California Department of Fish and Game Wardens Michael Sadleir and William Donovan caught a snowy owl while on patrol in the Yolo Bypass. The area where the bird was picked up is 10 miles south of Interstate Highway 80 near Davis, California.

This snowy owl, a male, was sick at the time the wardens caught it; it was sitting on a large drain pipe and made no attempt to avoid capture. The owl died a few hours after its capture, before treatment could be initiated. Autopsy revealed the presence of small, bipolar gram-negative bacilli in blood and liver impression smears. Subsequent culture and isolation of the organism, followed by biochemical characterization, revealed the organism to be *Pasteurella multocida*, the etiological agent of fowl cholera (Breed, Murray, and Smith, 1957).

It is assumed by the author that the owl became infected by feeding upon ducks infected with *P. multocida*. This assumption seems to be logical, since an outbreak of fowl cholera in the waterfowl had been under way for several days preceding January 4.

According to Grinnell and Miller (1944), the last recorded sighting of a snowy owl in California occurred in 1916. At that time there were several reports of sightings in Del Norte, Humboldt, and Butte counties. There have not been any published observations of snowy owls in California since the work of Grinnell and Miller. However, there have been a few unpublished sightings at various localities in California since 1916.

ACKNOWLEDGMENT

The author wishes to express his appreciation to Mrs. Harold Kimball, editor of the Sacramento Audubon "Observer", for checking Audubon records.

REFERENCES

Breed, Robert S., E. G. D. Murray, and Nathan R. Smith. 1957. Bergey's manual of determinative bacteriology. 7th ed. Williams and Wilkins Co., Baltimore. 1,094 p.

Grinnell, Joseph, and Alden H. Miller. 1944. The distribution of the birds of California. Cooper Ornithological Club, Berkeley. 608 p.

Brian F. Hunter, Wildlife Management Branch, California Department of Fish and Game, January 1967.

BIOLOGICAL NOTES ON SOUTHERN CALIFORNIA LANTERNFISHES (FAMILY MYCTOPHIDAE)[1]

INTRODUCTION

Lanternfishes, with about 300 nominal species, are among the most common fishes inhabiting the upper 1,000 meters of the world ocean. Whales (Marshall, 1954), seals, porpoises (Follett, 1952), seabirds (Alverson, 1961), sharks (Hubbs, 1917), and squid (nightlight observations) utilize lanternfishes as food. Salmon (Shimada, 1948), yellowfin tuna, skipjack (Alverson, 1961), albacore (McHugh, 1952), rockfish (Fitch, 1951), as well as a number of midwater fishes (Marshall, 1954), also have been reported as lanternfish predators. While myctophids are an important part of the oceanic food chain, little is known of their life history.

During a 2-year midwater sampling program in the San Pedro Basin, located between Santa Catalina Island and the southern California coast, 14 species of Myctophidae and one species of the closely related Neoscopelidae were collected (Table 1). The systematic work of Fraser-Brunner (1949) contains references and synonymies for all but two of the species. All specimens were taken with a 10-foot Isaacs-Kidd Midwater Trawl, fished from the University of Southern California research vessel *Velero IV*. An analysis of distribution was made for the lanternfishes of San Pedro Basin (Paxton, 1967). From the study collection of more than 16,000 specimens, about 300 adults with visibly distended abdomens were selected for dissection. Stomach contents and gonadal conditions were recorded from this biased sample. No record was kept when stomach contents were absent or digested beyond recognition, although this was relatively common. The presence of external copepod parasites from the entire study collection was noted.

STOMACH CONTENTS

Stomach contents from nine species were analyzed. The other six species of lanternfishes taken during the study were represented by only a few adults which had no identifiable stomach contents. *Stenobrachius leucopsarus*, *Triphoturus mexicanus*, *Symbolophorus californiensis*, *Diaphus theta*, and *Lampanyctus ritteri* seem to be highly specific feeders; *Tarletonbeania crenularis* and *Scopelengys tristis* may be, also (Table 1). Only 6 of the 196 specimens of these 7 species had stomach contents of more than one kind of organism. Aughtry (1953) also found 9 specimens of *T. crenularis* with only euphausiids in the stom-

[1] Part of a thesis submitted to the Department of Biological Sciences, University of Southern California, in partial fulfillment of the requirements for a Master of Science degree.

TABLE 1

Lanternfishes of the San Pedro Basin. Stomach Contents for Nine Species, Showing the Number of Specimens with Each Category of Food

Species	Number with identifiable remains	Crustaceans					Fishes			
		Euphausiidae	Copepods	Sergestidae	Amphipods	*Emerita sp.* larvae	Digested fish remains	*Bathylagus wesethi*	*Leuroglossus stilbius*	*Stenobrachius leucopsarus*
Stenobrachius leucopsarus (Eigenmann and Eigenmann)	95	69	10	8			4	--	3	1
Lampanyctus ritteri Gilbert	36	24	3	5	--	--	3	4	--	--
Triphoturus mexicanus (Gilbert)	38	37	2	--	--	--	--	--	--	--
Symbolophorus californiensis (Eigenmann and Eigenmann)	16	16	1	--	--	--	--	--	--	--
Diaphus theta Eigenmann and Eigenmann	7	7	1	--	--	--	--	--	--	--
Tarletonbeania crenularis (Jordan and Gilbert)	3	3	--	--	--	--	--	--	--	--
Scopelengys tristis Alcock*	1	1	--	--	--	--	--	--	--	--
Ceratoscopelus townsendi (Eigenmann and Eigenmann)	3	3	3	3	--	--	--	--	--	--
Lampadena urophaos Paxton	5	4	5	4	1	1	2	--	--	--
Totals	**204**	**164**	**25**	**20**	**1**	**1**	**9**	**4**	**3**	**1**

Species with no identifiable stomach contents

Protomyctophum crockeri (Bolin)
Diogenichthys atlanticus (Taaning)
Diogenichthys laternatus (Garman)
Taaningichthys bathyphilus (Taaning)
Lampanyctus regalis (Gilbert)
Parvilux ingens Hubbs and Wisner

* Family Neoscopelidae

ach contents. In contrast, at least three types of animal remains were present in each stomach of the limited sample of *Lampadena urophaos* and *Ceratoscopelus townsendi*.

Although it would appear that *S. leucopsarus* and *L. ritteri* consume a wider variety of food than the other species, the size range of the dissected fishes influenced the data. Individuals of the two species reached 90 mm SL and, in this limited study, fish remains were found only in specimens over 60 mm SL. Few individuals of the other species reached 60 mm SL, and with the exception of *L. urophaos*, none of these had fish remains in the stomach contents. Myctophids consume large amounts of food at one time, and the stomach is often distended and fills most of the coelomic cavity. In one specimen of *S. leucopsarus*, 19 undigested euphausiids were found. Crustaceans, particularly euphausiid shrimps, make up the main diet of the basin lanternfishes.

Lanternfish populations apparently feed both during the day and at night. An examination of trawl data reveals that 117 specimens with identifiable stomach contents were taken diurnally and 86 specimens were caught nocturnally.

PARASITES

Three lanternfish species are hosts of the parasitic copepod *Cardiodectes medusaeus* of the family Lernaeidae. *S. leucopsarus* is the primary host for the parasite in the basin, with 226 infected individuals, or 2.47% of the 9,143 captured specimens. One *L. ritteri* and four *D. theta* were also parasitized. From one to four parasites are found embedded in the ventral side of the fish, in the middle of the isthmus; the head enters the *bulbus arteriosus* of the host. The parasite has been figured by Shiino (1958).

REPRODUCTION

Captures of postlarval fishes indicate that nine of the resident lanternfishes breed in or near the San Pedro Basin. The six species for which no young have been taken are also among the least frequently captured: *Diogenichthys laternatus*, *Taaningichthys bathyphilus*, *Lampadena urophaos*, *Lampanyctus regalis*, *Parvilux ingens*, and *Scopelengys tristis*. The San Pedro Basin is at the extreme of the geographic ranges of *D. laternatus*, *T. bathyphilus*, and *S. tristis*. These species may be expatriates, unable to reproduce within the basin environment.

Dissections revealed gravid females of *S. leucopsarus*, *T. mexicanus*, and *L. ritteri*, the three most common basin species. Few individuals of the other species were dissected. Gravid females of *S. leucopsarus* were taken from October through April, and of *T. mexicanus* from June through September. While fewer adult specimens of *L. ritteri* were examined, gravid females were captured in January, June, August, October, and December, which suggests a year-round breeding season. The occurrence of 15–17 mm postlarvae of *S. leucopsarus* and *T. mexicanus* during five months of the year supports the hypothesis of a long breeding season for these species. A 9-month breeding season, from November to August, is reported for *S. leucopsarus* in Monterey Bay (Fast, 1960). In the San Pedro Basin, high summer temperatures and salinities may prevent this subarctic-transitional species from breeding. Possible competition with the summer breeding *T. mexicanus* may limit the breeding season of *S. leucopsarus*.

ACKNOWLEDGMENTS

The guidance and criticism of Jay M. Savage, University of Southern California, is gratefully acknowledged. John S. Garth and Russel L. Zimmer, University of Southern California, criticized the original manuscript. The sampling program was carried out under support from a National Science Foundation grant (G-10691). Gordon Hewitt, Victoria University of Wellington, New Zealand, kindly identified and provided information about the parasites.

REFERENCES

Alverson, Franklin G. 1961. Daylight surface occurrence of myctophid fishes off the coast of Central America. Pac. Sci., 15 (3) : 483.

Aughtry, Robert H. 1953. A note on mass mortality of the myctophid fish *Tarletonbeania crenularis*. Copeia, 1953 (3) : 190–192.

Fast, Thomas N. 1960. Some aspects of the natural history of *Stenobrachius leucopsarus* Eigenmann and Eigenmann. Stanford Univ., Ph.D. Dissertation, 107 p.

Fitch, John E. 1951. Studies and notes on some California marine fishes. Calif. Fish and Game, 37 (2) : 111–120.

Follett, William I. 1952. Annotated list of fishes obtained by the California Academy of Sciences during six cruises of the U.S.S. *Mulberry* conducted by the United States Navy off central California in 1949 and 1950. Proc. Calif. Acad. Sci., Ser. 4, 27 (16) : 399–432.

Fraser-Brunner, A. 1949. A classification of the fishes of the family Myctophidae. Proc. Zool. Soc. London, 118 (4) : 1019–1106.

Hubbs, Carl L. 1917. A note on the food of *Squalus sucklii*, the California dogfish. Copeia, 1917 (43) : 37–38.

Marshall, N. B. 1954. Aspects of deep sea biology. Hutchinson and Co., Ltd., London, 380 p.

McHugh, J. L. 1952. The food of albacore (*Germo alalunga*) off California and Baja California. Bull. Scripps Inst. Ocean., 6 (4) : 161–172.

Paxton, John R. 1967. A distributional analysis for the lanternfishes (family Myctophidae) of the San Pedro Basin, California. Copeia, 1967 (2) : 422–440.

Shiino, Suco M. 1958. Copepods parasitic on Japanese fishes. 17. Lernaeidae. Rept. Fac. Fish. Univ. Mie, 3 (1) : 75–100.

Shimada, Bell M. 1948. Records of lanternfish in Puget Sound. Copeia, 1948 (3) : 227.

—*John R. Paxton, Dept. of Biological Sciences, University of Southern California, Los Angeles, Calif. 90007, October 1966.*

ALBINOID COLORING IN A SAND BASS, *PARALABRAX NEBULIFER* (GIRARD)

On July 14, 1965, the sportfishing boat *Palamar*, Jim Alvarez skipper, landed a very light-colored sand bass, 257 mm SL, while fishing in the yellowtail kelp area about 8 miles northwest of Oceanside, California, and 1 mile offshore, opposite the San Onofre power plant (Figure 1). A deckhand, Greg Smith, preserved the fish because of its unusual coloration, and brought it in to Cerritos College, Norwalk, California. Notes on the color pattern of the specimen were made after it had been in formaldehyde for 2 days.

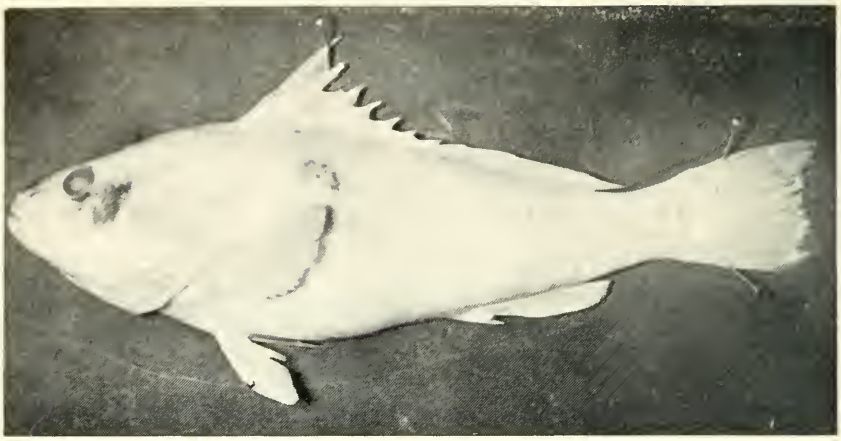


FIGURE 1—Sand bass, *Paralabrax nebulifer* (Girard), showing albinoid coloring. *Photograph by Dean Gross.*

The sides and belly of the fish were white, and the dorsal surface was a light yellow with some faint, scattered, darker irregular mottling. There was a black blotch under the spinous dorsal, one beneath and slightly behind the orbit, and a single blotch on the middorsal line in the nasal region. A reddish-orange patch, running parallel to the border of the maxillary, extended from a region anterior to and below the level of the orbit to the posterior margin of the preopercle. The dorsal fin was yellowish, with black tips on the first three spines. The caudal and pectoral fins were a light yellow. The remaining fins were white.

Mr. Smith reported that a "legal size" sand bass (minimum length, 12 inches from tip of jaw to longest lobe of tail) with similar markings had been caught about two weeks earlier approximately a quarter mile away by the sportfishing boat *Sea Lure*. However, it was not saved.

The specimen has been deposited in the fish collection of the Los Angeles County Museum of Natural History (LACM 6993-1).

—Jules M. Crane, Jr., Biology Department, Cerritos College, Norwalk, California, August 1966.

PREDATION UPON PACIFIC HAKE, *MERLUCCIUS PRODUCTUS*, BY PACIFIC DOGFISH, *SQUALUS ACANTHIAS*

A mixed catch of Pacific hake and dogfish taken at Port Susan, Washington (an arm of Puget Sound, 30 nautical miles north of Seattle), on May 18, 1966, contained 20% by weight dogfish. The fish were schooled at 48 fathoms over a 65-fathom bottom, and were caught in a large midwater trawl by the U. S. Fish and Wildlife Service vessel *John N. Cobb* during an investigation of the hake resources in Puget Sound. A new commercial hake fishery was started in this area in the winter of 1965–66.

The hake in the catch ranged from 12 to 25 inches, with a mode of 14 inches, FL. In a random sample of 207 hake, 192 were males, a phenomenon that seems peculiar to the spawning period; usually the sexes are more evenly mixed. Most of the male hake were ripe, and milt flowed freely when the fish were lightly squeezed.

The dogfish were mostly large females, 2½ to 3 feet long, carrying young with attached yolk sacs. Of 52 dogfish stomachs examined, 25 contained hake. Most of the hake had been bitten neatly in two, and either the anterior, posterior, or both halves swallowed. Other species in the dogfish stomachs included Dungeness crab (*Cancer magister*) and Pacific herring (*Clupea harengus pallasii*).

Clemens and Wilby (1961) reported that dogfish appear in large numbers where herring school and that they feed on a variety of the smaller fishes. The observed feeding of dogfish on schooling hake is consistent with this behavior.

REFERENCE

Clemens, W. A., and G. B. Wilby. 1961. Fishes of the Pacific Coast of Canada (2nd ed.). Bull. Fish. Res. Bd. Canada (68) :82.

—Herbert H. Shippen and Miles S. Alton, U. S. Bureau of Commercial Fisheries, 2725 Montlake Blvd. E., Seattle, Washington 98102, August 1966.

REPORT ON AN ATTACK BY A GREAT WHITE SHARK OFF COLEDALE BEACH, N.S.W., AUSTRALIA, IN WHICH BOTH VICTIM AND ATTACKER WERE RECOVERED SIMULTANEOUSLY *

On the 26th of February, 1966, a shark was caught and killed after it had attacked a 13-year-old schoolboy, on a southeastern Australian beach. The shark was captured because it did not release its victim, forcing rescuers to carry both the boy and shark ashore. The shark's jaws had to be prized open on the beach to free the boy's leg. Apart from being one of the rare instances where the species could be identified accurately, it is believed that this is the first recorded case where a shark attack has ended in the manner outlined above.

PARTICULARS OF THE VICTIM

Raymond Short of Carrington Avenue, Hurstville, Sydney, was on a camping holiday with his parents and brother at Coledale Beach. He was of average height, lightly suntanned, and wearing dark green nylon swimming trunks with a small yellowish stripe at the time of the attack.

* *Editor's Note:* This species of shark is also responsible for some attacks along the coast of California.

LOCALITY OF ATTACK AND ENVIRONMENTAL CONDITIONS

The victim was one of about 50 people bathing at Coledale Beach (lat. 34° 17′ S., long. 150° 56′ E.), a small coastal resort situated about 10 miles north of the town of Wollongong, on the South Coast of New South Wales. The beach is a shallow sandy cove about 300 yards long, bounded to the north and south by low rocky headlands. The beach shelves gently out to sea, and is regarded by the Coledale Surf Club as reasonably free from strong rips and undertows.

The attack occurred at 2 p.m. in 5 feet of water about 30 yards from the shore. The sky was clear, the air temperature 70.0 F, and the water temperature 71.2 F. There was a light south to southeast wind, and a light but confused and choppy surf. Due to strong winds and heavy seas towards the latter part of the previous week, the water was very murky.

DESCRIPTION OF THE ATTACK AND RESCUE

The victim, who had just started to tread water, was first seized on the left thigh and then on the lower part of the right leg. He endeavored to fight the shark off and bit it on the snout to make it release its grip but without effect. The boy screamed for help, the shark warning bell was rung, and the other bathers promptly fled from the water. Raymond Joyce, a surf club member, first reached the victim, who said "help me please—the shark is still there." Owing to the murkiness of the water, the rescuer could not see the shark and did not believe the victim until he endeavored to drag him ashore. Five other lifesavers then arrived, and they too were unaware that the shark was still grasping the boy's leg despite the latter's repeated assertions that it was. Joyce than ran his hand down the boy's leg and felt the shark; another rescuer immediately raised the boy's leg to the surface and exposed the shark for the first time. At this stage another rescuer started clubbing the shark's head with a surfboard. When this proved unsuccessful the rescuers, with great courage, seized the shark by the tail, and half carried and half dragged both the boy and shark ashore. During the rescue the boy bled profusely and the water around him was stained with blood.

On the beach the shark's jaws were forced open and the boy's leg released. The lifesavers estimated that only 30 seconds elapsed from the victim's initial screams until they reached him and a further 30 seconds were taken to bring him ashore.

DESCRIPTION OF INJURIES AND TREATMENT

The boy was gravely injured and in a deeply shocked condition; he was also suffering from severe loss of blood. Providentially the District Hospital was situated on the northern headland only about 300 yards from the scene of the attack. The boy was wrapped in towels, loaded into a station wagon and rushed to the hospital. It was estimated that only about 8 minutes had elapsed between the attack and the boy's admission to the hospital. However, in this short time his condition had deteriorated rapidly and he was on the point of death.

The injuries comprised loss of calf muscles and all muscular tissue of the posterior part of the right leg; the shinbone was exposed and bore imprints of the shark's teeth along its full length. On the left

leg there were multiple lacerations to the front and back of the thigh. The index, middle, and ring fingers of the right hand were badly lacerated, and there were deep lacerations to the palm and wrist of the left hand. Transfusion entailed 8 pints of blood and 200 stitches were required. The victim has recovered and although the right leg has been saved it will probably be withered and may require a brace.

IDENTIFICATION AND DESCRIPTION OF THE SHARK RESPONSIBLE FOR THE ATTACK

After being dragged ashore the shark was allowed to die on the beach. It was identified by the authors as an immature female great white shark, *Carcharodon carcharias* (Linnaeus), measuring 8 feet 3 inches overall. This species is easily recognized by the large, triangular serrated teeth in the upper and lower jaws, and the strongly lunate caudal fin. The great white shark is reputed to be one of the most dangerous of all sharks because of its aggressiveness and ferocity, and according to Garrick and Schultz (Gilbert, 1963), responsible for more attacks on men and beasts than any other species.

Detailed examination of the shark on the day following the attack revealed massive wounds of comparatively recent origin on the left and right lower abdominal surfaces, and on the dorsal and ventral region of the tail between the pelvic and caudal fins. There were also multiple lacerations and parallel scratch marks over this whole area (Figure 1). The small injuries had healed over completely and the major ones appeared to be healing well. One wound on the ventral surface, between the caudal and pelvic fins, was elliptical in shape, each half forming the typical parabolic curves of the upper and lower

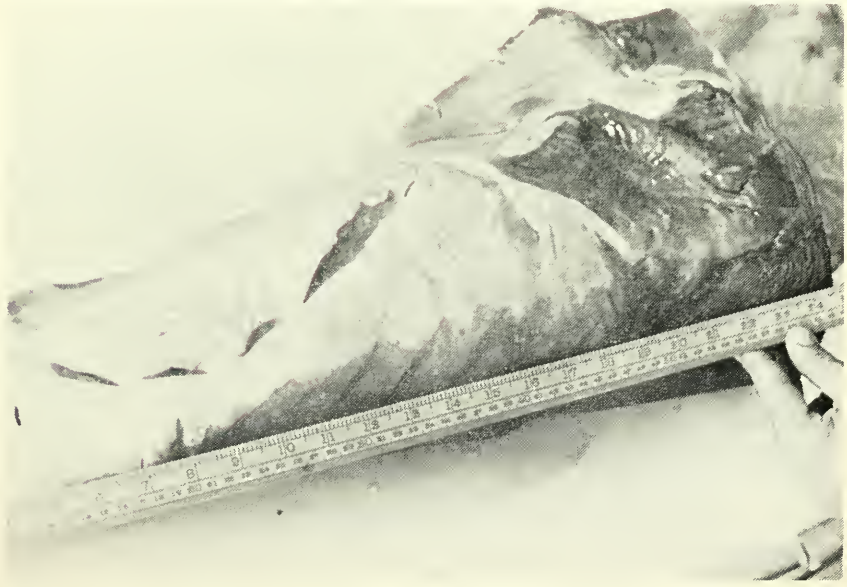


FIGURE 1—Left, ventral, abdominal surface of the shark, showing massive wounds. *Photograph by P. H. Wolf, March 1966.*

FIGURE 2—Ventral view of the posterior abdominal region. The wound caused by the shark bite is recognizable. *Photograph by P. H. Wolf, March 1966.*

jaws of a shark (Figure 2). This was undoubtedly a shark bite, and the 9-inch width and 5-inch gape of the wound indicated that the attacker was approximately the same size as its victim. An X-ray of the area did not locate any tooth fragments, and established that the vertebral column was undamaged.

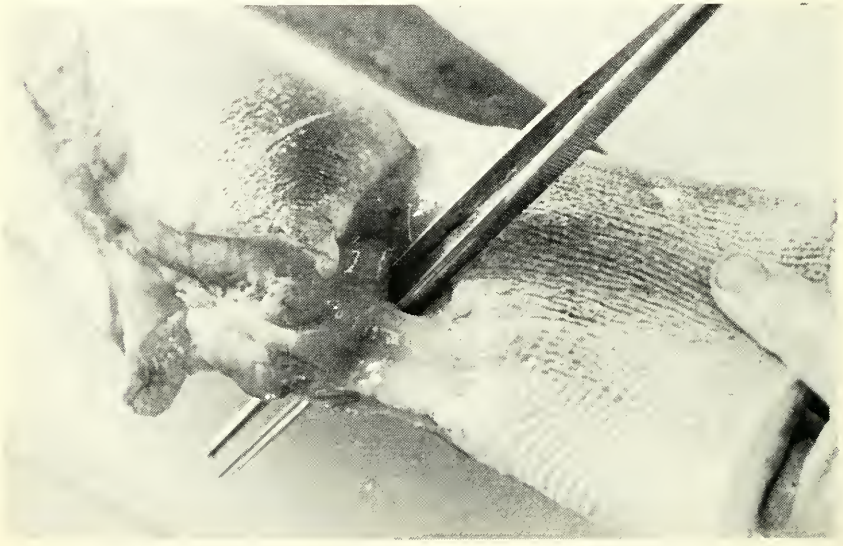


FIGURE 3—Wound opening into the abdominal cavity on the ventral surface. *Photograph by P. H. Wolf, March 1966.*

In addition to the above injuries, a 10-inch wound ran anteriorly from the right pelvic fin 5 inches then turned upward at a right angle. This wound had penetrated the abdominal cavity, leaving a triangular

hole 2 inches wide at the base and 4½–5 inches high. Much of this cavity had healed over, but a small cylindrical aperture about 0.4 inch in diameter still remained open to the outside, and it was possible to insert a finger through this hole into the abdominal cavity (Figure 3).

The severity and extent of these injuries suggested that the shark's ability to catch natural prey may have been impaired. However, stomach analysis revealed two pieces of undigested squid, about 2 dozen vertebrae from a fish weighing between 1 and 2 pounds, and about 2 pints of viscous brown liquid.

The most remarkable feature of the attack was the shark's lack of aggression during the rescue operations. It is probably that this may have been related to the severity of its wounds.

SPECIAL NOTES

This attack has a number of features in common with the majority of attacks in Australia (Coppleson, 1962). It occurred during the summer months when the water temperature exceeded 68.0 F; it occurred in the afternoon; the victim was a male aged between 12 and 22 years; it occurred close to shore in shallow water; and the attack was on the legs.

The attack was given headline coverage by the press, and by television and radio stations. Reporters identified it variously as a blue pointer, whaler, grey nurse, and a white pointer. If these identifications are an index of the reliability of on-the-spot observations by laymen, the amount of reliance that can be placed on identifications where the shark is only briefly sighted during the horror and panic of an attack is exceedingly small. According to Schultz (Gilbert, 1963), in 1,004 shark attacks less than 4% of the sharks were positively identified.

ACKNOWLEDGMENTS

The authors are indebted to the attending physician, M. Rosen, Kennedy Road, Austinmer, N.S.W. and to Matron Dunster, Coledale District Hospital, for photographs and descriptions of the injuries; to A. Stein, N.S.W. Fisheries Branch, for preserving the shark for detailed examination; and to members of the Coledale Surf Club, who participated in the rescue, for detailed accounts of events during and subsequent to the attack.

REFERENCES

Coppleson, V. M.
1962. Shark attack. Angus and Robertson, Sydney, 269 p.

Gilbert, Perry W., editor
1963. Sharks and survival. D. C. Heath and Co., Boston, 578 p.

—T. B. Gorman and D. J. Dunstan, Fisheries Branch, Chief Secretary's Department, 211 Kent Street, Sydney, Australia, November 1966.

BOOK REVIEW

Underwater Guideposts: Homing of Salmon

By Arthur D. Hasler; The University of Wisconsin Press, Modison, 1966; xii + 155 p., illustrated. $6.

It is now well recognized that salmon do migrate hundreds or even thousands of miles and return to their home river system and home tributary to spawn. Man has even learned a moderate amount about the abilities or "mechanisms" which could make it possible for fish to find their way, but a great deal more will have to be learned before this latter subject can be classed as well-understood.

The title of this book might lead a reader to believe that salmon are the only species considered, but much of the basic information was obtained by working with several other species. Arthur Hasler has assembled the important known facts and theories on salmon migration and on the mechanisms by which fish are able to orient themselves. Much of the experimental work has been done by the author and his associates since 1950 or a little before.

The book is divided into three parts, the first of which is on the stream phase of salmon homing. The author briefly discusses some disproven theories and then takes up the odor hypothesis, which is (briefly) that salmon recognize their home river system and home tributary by the odor of the water. Hasler describes in interesting detail a series of experiments which show that bluntnose minnows can distinguish between waters from different streams. Other experiments show that salmon can recognize the odor of a stream, and that salmon with sense of smell intact can and do find their home tributary, but that salmon deprived of their sense of smell cannot.

Salmon transferred as eggs to another stream are now known to return to the stream of their youth rather than to the stream of their ancestors. The ramifications of this are discussed, but not at great length.

An interesting but as yet unanswered question is asked: Could salmon be switched to another stream by the use of decoy odors? There are experiments in progress which may or may not partially answer this. The implications for salmon management could be important.

Part II of the book is on oceanic phases of salmon homing. The author explains that until after World War II "it was generally believed that salmon stayed on the continental shelves of the oceans after they had emigrated from their home streams." He implies that it was generally believed (by salmon biologists?) that salmon in the ocean remained within the influence of their home streams. (This reviewer agrees with the first of these two statements but not with the second.) When the Japanese started catching huge numbers of salmon far at sea, the need for more knowledge of salmon oceanic habits suddenly became acute. Hasler devotes most of a chapter to describing the resulting international investigations and their findings. These findings pointed up the need for a hypothesis to explain how salmon find their way home across open ocean.

There appears to be a strong possibility that salmon navigate by the sun. Orientation by "sun-compass" is quite complex in that it involves corrections for the time of day, the time of year, and sometimes the latitude. Hasler describes experiments in which fish which were trained to go in a certain direction to find food or cover demonstrated that they could correct for all three of these things, but only if the sun was visible. Several species of freshwater fishes were involved in the tests, but salmon were not. It is not yet positively known whether salmon orient themselves by sun-compass or can use the altitude of the sun to determine whether they are north or south of their goal. Even if they do these things, supplementary theories may be required to account for apparent ability to orient at night or during cloudy weather. Other possibilities and studies, including the mathematical model which Saila and Shappi used to test the possibility that random movement could be a major factor in salmon migration, are discussed.

Part III, "Closing the Migration Circle", is much the shortest part of the book. It includes various aspects of seaward migration and an overall summary. Seaward migration seems fairly easy to explain in streams, but in Babine Lake, British Columbia, young sockeye salmon reared in the Morrison Arm of the lake show definite orientation as they swim south until opposite the arm which leads to the outlet, then move west into that arm and north again to the outlet. This appears to be an inherited procedure.

Anyone who is interested in migrations or in fish will find this book well worth reading. For the serious student of salmon or of fish migrations, it is a must.—*Donald H. Fry, Jr.*

printed in CALIFORNIA OFFICE OF STATE PRINTING
93994—800 4-67 5,300

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Editor, CALIFORNIA FISH AND GAME
CALIFORNIA DEPARTMENT OF FISH AND GAME
1416 9TH STREET, SACRAMENTO, CALIF. 95814

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